Prepared for:

BC Ministry of Sustainable
Resource Management,
Muskwa-Kechika Advisory Board
and the
BC Oil and Gas Commission

MUSKWA-KECHIKA MANAGEMENT AREA HELIPORTABLE DRILLING FEASIBILITY STUDY

Prepared by:

Randal Glaholt and Lois Pittaway
TERA Environmental Consultants
Suite 1100, 815 - 8th Avenue S.W.
Calgary, Alberta T2P 3P2

Brian Churchill

Chillborne Environmental Services
SS2 Site 22 Comp 23
Fort St. John, BC V1J 4M7

Harris Wheeler
AAEA Ltd.
Charlie Lake, BC V0C 1H0

June 2002
2555

ACKNOWLEDGEMENTS

TERA Environmental Consultants, in association with Chillborne Environmental Services and AAEA Ltd. would like to gratefully acknowledge a number of people who donated information and considered thought to this undertaking. The authors would like to thank the following individuals:

Ackerman, Andy	Ministry of Water, Land and Air Protection, Fort St. John, BC
Adamson, Murray	Canadian Helicopters, Fort St. John, BC
Atwell, Dale	Helmerich and Payne Drilling Inc., Tulsa, Oklahoma
Backmeyer, Rod	Ministry of Water, Land and Air Protection, Fort St. John, BC
Braden, J.	Halliburton Energy Services, Houston, Texas
Cazes, Bruce	BC Oil and Gas Commission, Fort St. John, BC
Clark, Mr.	ATCO Structures, Calgary, Alberta
Cole, Orville	Fire Creek Resources, Calgary, Alberta
Crowson, Randy	Parker Drilling, Houston, Texas
Darrow, Danny	Waberski Darrow, Fort St. John, BC
Devries, D.	Finning Canada, Calgary, Alberta
Doyle, Derek	BC Oil and Gas Commission, Fort St. John, BC
Evacek, Doug	Precision Drilling, Calgary, Alberta
Glenn, Les	BC Oil and Gas Commission, Fort St. John, BC
Hunley, Tony	Airborne Energy Solutions, Calgary, Alberta
Krezanoski, Dave	BC Oil and Gas Commission, Fort St. John, BC
LaChance, J. P.	Marathon Canada Limited, Calgary, Alberta
Luft, Barry	Fire Creek Resources Ltd. Calgary, Alberta
Matheson, Andre	Reeves Wireline, Red Deer, Alberta
McDermid, Gary	Helifor Industries Limited, Vancouver, BC
Miller, Mike	Safety Boss, Calgary, Alberta
Miltenburger, Gary	BC Oil and Gas Commission, Fort St. John, BC
Mitchell-Banks, Ben	BC Oil and Gas Commission, Fort St. John, BC
Pare, Treena	Drillers Technology Corp., Calgary, Alberta
Patterson, Bernie	Marathon Canada Limited, Calgary, Alberta
Peterson, Todd	Columbia Helicopters, Portland, Oregon
Phillips, B.	Workers' Compensation Board of BC, Fort St. John, BC
Pow, Murray	Husky Energy Inc., Calgary, Alberta
Reid, Mike	Shell Canada, Calgary, Alberta
Shepert, Ray	Murphy Oil Company Ltd., Calgary, Alberta
Sroka, G.	Access Waterwells Inc., Edson, Alberta
Staniland, Rob	Talisman Energy, Calgary, Alberta
Taylor, Corey	Vancouver Island Helicopters, Fort St. John, BC
Thatcher, D.	Sanjel Corporation, Calgary, Alberta
Wolford, Simon	Anderson Waterwells, Fort St. John, BC
Ziebell, Trevor	Murphy Oil Company Ltd., Calgary, Alberta

Also Wayne Sawchuk, Kaizen Environmental Services Inc. and Helifor Industries Limited for some of the photos used in the reports.

EXECUTIVE SUMMARY

Background on Heliportable Drilling, Regulatory and Policy Review

The potential use of helicopter supported drilling (heliportable drilling) for oil and gas exploration in environmentally sensitive areas of northeastern British Columbia been actively debated and considered for many years. It has thus far been rejected by either the proponent and/or the government based on concerns over safety, blow-out control, sour gas, cost, scheduling constraints, rig availability, lack of experience and availability of alternatives.

Despite these concerns, there remains a strong environmental interest in the potential application of heliportable drilling within environmentally sensitive areas of BC. This interest has been fueled in part by the awareness of heliportable drilling being successfully carried out elsewhere in the world, a belief that the concerns raised by heliportable drilling can ultimately be addressed and a concern that the significant ecological and social values of the Muskwa - Kechika Management Area (herein referred to as the MK) are deserving of exceptional protective measures where industrial development is to be allowed. The goal of the present study was to examine the costs, benefits and feasibility of helicopter-supported exploration drilling given the environmental operating conditions found in the MK.

Interviews conducted for the purpose of this study revealed that the industry's current concerns in regard to heliportable drilling are related to economics, safety and the availability of suitable equipment.

Existing legislation and regulations that are relevant to the question of helicopter-supported oil and gas operations were reviewed. Legislation and regulations included the *Petroleum and Natural Gas Act* and regulations, the BC Oil and Gas Handbook, the *Workers' Compensation Act* and companion Occupational Health and Safety Regulations, the *Muskwa-Kechika Management Area Act* and the Maximum Disturbance Review Criteria Code and Guideline. Based on this review and discussions with the Workers' Compensation Board of BC (WCB) and the BC Oil and Gas Commission (BC OGC), there are no significant regulatory constraints to heliportable drilling provided in the legislation and regulations.

Environmental Report

The Environmental Report provides background biophysical and resource management information on the MK of relevance to the feasibility of heliportable drilling. The environmental impacts of conventional roads and helicopters are discussed along with their implications for subsequent development and production.

The MK is 6.4 million hectares in size and remains one of North America's last true wilderness locations south of the 60th parallel. Activities in the MK are guided by the *Muskwa-Kechika*

Management Area Act that identifies the MK as an area of unique wilderness in northeastern BC that is endowed with a globally significant abundance and diversity of wildlife. The management intent for the MK is to maintain in perpetuity the wilderness quality and the diversity and abundance of wildlife and the ecosystems on which it depends, while allowing resource development and use in parts of the MK designated for those purposes including recreation, hunting, timber harvesting, mineral exploration and mining, oil and gas exploration and development.

Motorized vehicle travel is limited to designated routes within the MK that were determined on the basis of environmental sensitivity, public recommendation and past use.

Terrain conditions affect the level of difficulty and impact for both conventional and heliportable drilling operations. Narrow ridgelines and steeply sloping terrain are particularly difficult places to operate and to minimize impact. Conventional road construction in these areas, tends to result in much larger impacts due to soils handling requirements, particularly due to side cast fill. To some extent, these impacts can be reduced by end-hauling excavated material and then restoring this material following site abandonment. Surface stabilization and vegetation re-establishment in such sites is particularly challenging and requires long-term commitment and attention. Locations in deeply incised valleys and small cirques often have associated climatic conditions that would present greater constraints for helicopter operation due to phenomenon such as turbulence and down drafts. Higher altitude sites pose a further constraint on heliportable operations as a result of the reduced lifting capacity of helicopters with increasing altitude, though this is not an overriding constraint on heliportable operations.

Drilling programs within the eastern third of the MK will tend to encounter sweet Mississipian gas and as such, incur lower relative risk and risk management requirements than potentially Devonian plays to the west. However, as a matter of practice, drilling protocols in BC treat all wells as potentially sour. To the extent that a company's risk management protocol requires road access for sour gas exploratory wells, consideration or application of heliportable drilling would be restricted to easterly Mississippian formations. It would appear there may be somewhat greater potential for any blow-out event in Mississippian formations to include variable volumes of water and as such require an appropriate level of supervision and contingency planning. Easterly Mississippian plays will tend to be shallower than those in the westerly Devonian and as such potentially have access to a greater number of heliportable rigs. Regardless of sour gas presence, it is likely that generally larger (greater depth capability) heliportable rigs will be required for drilling targets in the western portion of the MK, though this will vary considerably with each location. As discussed in the Technical Report, larger heliportable drilling rigs are at this time, more commonly engaged outside of North America.

It is likely that drilling targets will tend to be identified on top of, or immediately adjacent to more mountainous topography, rather than in broad valley bottoms. These drilling targets will typically require more physical disturbance for conventional road accessed wells, likely require more ambitious directional drilling for conventionally accessed wells, as well as potentially pose more demanding flying conditions for a heliportable operation. Heliportable locations would likely result in less regulatory pressure for directional drilling to offset environmental impacts. In either case, the constraints on the access approach will be site-specific.

Climatic conditions occurring in the MK of relevance to heliportable drilling include cold temperatures, high winds, fog and low cloud cover and icing. The frequency of occurrence and location of these conditions is highly variable. The occurrence of "no fly" conditions for the purpose of heliportable drilling is expected to be uncommon and typically restricted to portions of a given day rather than preclude flying for the entire day.

Alpine tundra vegetation is highly sensitive to disturbance and is very slow to re-establish once disturbed. Unless alpine terrain is very gentle, low impact road construction (*e.g.*, using snow fill or other padding) is not possible. In this context, relatively greater impacts will occur using conventional road access compared with heliportable. Where there is a requirement to more aggressively reclaim and monitor alpine reclamation, a company could encounter potentially significant manpower and financial commitment. New road construction through forests within the MK would inevitably result in creation of a scar in the vegetation mosaic with attendant impact on the wilderness landscape aesthetic associated with the area. The presence of valley bottom areas dominated by willow, dwarf/scrub birch and/or meadows provides some opportunity for low impact road construction as an alternative to a heliportable operation. These vegetation communities provide the opportunity for construction of temporary winter access by walking over the vegetation and building snow/ice roads (with or without mowing) with potentially only minor impact to the landscape aesthetic and functional integrity of the affected vegetation communities.

The presence of high value and relatively high sensitivity fishery resources within the MK increases the need for fisheries specific research, planning, design and permitting where it involves conventional road construction. Heliportable access eliminates potential impacts caused by erosion, riparian habitat loss and human fishing pressure to fish and aquatic ecosystems associated with more conventional road access, as well as the costs and time associated with assessment and planning around these. Potential for spills during fuel hauling can arise with both conventional road accessed drilling programs as well as for heliportable drilling programs.

Wildlife can be significantly affected by both roads and helicopter activity though these impacts tend to be site-specific. In general, much greater and more prolonged impacts are typically associated with roads. Displacement effects related to roads and helicopters appears to be a function of their proximity to key habitats, the level of activity and the manner in which species are exposed to that activity. Where alternate low impact road access is not available, heliportable drilling operations provide a much greater opportunity to avoid long-term impacts to wildlife habitat and wildlife, particularly for lower success rate exploration drilling. However, there remains some potential that heliportable operations could result in significant short-term stress and displacement of wildlife. The potential for longer-term range abandonment could occur where frequent helicopter site visits are required to locations within critical wildlife habitat or which may require low level flying enroute to a given location. The species with greatest potential to be impacted in this regard are likely Stone's sheep and mountain goat due to their strong reaction to helicopters and low flying aircraft, as well as grizzly bear when this species may seasonally seek more open terrain.

Use and creation of conventional road access in this land use setting can, if sensitively planned, for some interests and individuals, create a desired and improved resource access alternative. For others, road development is believed to lead to a significant degradation of the environment and associated opportunities (*e.g.*, guide outfitting and trapping). Heliportable drilling has potential to alleviate some of these latter concerns, but it's associated noise and activity can impair recreational experiences. To some extent, these helicopter impacts can be avoided through planning flight patterns and seasonal and daily timing restrictions, keeping in mind however, the desirability of maximizing daylight flying hours.

Guide outfitting success depends largely on the ability of guide outfitters to provide a high quality wilderness experience and a reasonably good chance for the client to obtain a trophy animal. Road construction for oil and gas exploration and development results in relatively long-term alteration of the landscape aesthetic and solitude, and has the potential to result in generally increased human use for motorized and equestrian access, unless this is effectively controlled. This increased access has the potential to increase industrial and recreational noise levels, as well as increase wildlife displacement and mortality. While guide outfitters may benefit by some limited access development, the overall effect of conventional road construction degrades the wildland experience and reduces the guide outfitter's ability to compete in the market place. Secondary support services such as airlines, hotels and other local businesses may also be affected. Confining oil and gas activity to the winter period in general, reduces overall impacts to guide outfitting though still results in some long-term adverse impacts, particularly where roads result in the creation of long-term unregulated access and degradation of the visual landscape.

Conventional winter and all-weather road construction has been suggested to interfere with trapping activities by obstructing trapper movement, as well as indirectly through affecting furbearer habitat and movement patterns. Heliportable drilling would avoid these impacts.

Heliportable drilling avoids most of the long-term physical impacts of road development such as landscape modification and increased conventional access. These impacts are traded off with increased wide spread noise impacts and increased potential for displacement of sensitive high valued wildlife species in the MK such as Stone's sheep. Such impacts may be short-term where a well is unsuccessful, however, in the production scenario, helicopter noise impacts on the wilderness experience and wildlife would be extended through a longer period (*e.g.*, many years). Adjustments to flying routes, scheduling of flights and specifying the type of helicopter may offset some of these impacts. Such adjustments may or may not add additional flying time and costs to heliportable operations. Adjustments to seasonal flying opportunities would have to be reconciled with interests in maximizing the daylight hour flying opportunities.

Development of unrestricted conventional road access provides the potential opportunity for physically, improved access for equestrian users and clearly improves accessibility by motorized vehicle users. In the absence of effective management policies, this can in turn put motorized vehicle users in conflict with horse or foot-based recreationists including commercial backcountry operators not using motorized access. A helicopter based exploration program avoids the physical impacts of conventional road access and to some extent can be seen to replace the physical impacts with more intense acoustic impacts. Studies in other jurisdictions have confirmed that aircraft use is incompatible with the public's perception of the proper management and use of protected areas. Similar concerns were also raised for other forms of motorized recreation.

Conventional oil and gas access road development within areas also targeted for timber harvest affords some opportunity to subsidize road building costs for forest operators or mining interests and conversely road development by the forest industry provides some opportunity to subsidize or defray road building costs associated with oil and gas activity. In some cases, oil and gas access roads have advanced timber harvest schedules where the two activities overlap and would be avoided in cases where heliportable drilling occurs.

A range of mitigation measures are available to reduce the potential impacts of both a heliportable drilling operation and more conventional land-based access. The magnitude of difference in environmental impact between the two basic alternatives is site-specific and may range from negligible to very significant. While in most cases, relatively less physical impact will be associated with heliportable operations there may be cases where these exceed that of conventional low impact winter road construction. An example of this circumstance would be where a snow or ice fill road with minimal clearing requirements could be constructed in a narrow valley bottom adjacent to occupied sheep or goat habitat.

A decision to allow road access during the production phase would negate the long-term benefits of heliportable drilling for successful wells. Where roads are constructed for long-term production, potential indirect impacts on wildlife populations caused by displacement from human activity (as opposed to predator avoidance) could be minimized by reducing the level of human activity on these roads. This could be achieved by allowing winter only industrial use as well as gated access, combined with enforcement, monitoring and education programs to control public use. Further investigation of the costs and benefits of various forms of access during operations is warranted.

Consideration should be given to identifying and mapping areas where the potential for low impact alternatives exist, as well as areas which may be more suited to helicopter access only. In addition, the practicality and economics of heliportable only access to the operations phase of oil and gas development should also be explored further.

Technical Report

The technical feasibility of heliportable drilling depends in part on the availability of depth rated heliportable drilling rigs and the ability of helicopters to deliver a level of critical support necessary for mobilizing, drilling and completing a deep sour gas well. At least four heliportable rigs are available in North America and are reported to have capability to drill to 3,400 m depth. Heliportable rigs with capability to drill sour wells in excess of 5,000 m are working in other parts of the world and can be mobilized via heavy transport aircraft if rapid delivery is required (assuming they are free to be released). Obtaining the services of these larger rigs would require longer pre-planning for mobilization. While re-configuring a conventional rig to be heliportable is technically feasible, and perhaps half the cost of constructing a new heliportable rig, the drilling contractors approached during this study believed the construction of a purpose-built heliportable rig was a more appropriate engineering solution.

A range of heavy-lift helicopters capable of mobilizing all components of heliportable rigs and providing adequate support during potential heliportable operations are available in North America. Carefully planning helicopter use is required to maximize the efficiency of rig moves in order to adequately control the overall cost, time and safety of a heliportable drilling operation.

Assessing the ability of a heliportable drilling program in the MK to provide adequate emergency medical response capability and well control capability has been viewed as a fundamental determinant to the technical feasibility of heliportable drilling. While it is technically feasible to provide 24-hour helicopter support to a heliportable drill site, it is apparent that numerous remote work sites exist in BC which do not have guaranteed 24-hour emergency access for long-distance medical evacuation and at the same time comply with requirements of the Workers' Compensation Board of BC (WCB). The WCB has expressly stated that it would not prohibit heliportable drilling or require guaranteed 24-hour emergency access, provided normal requirements for remote work site medical facilities are met. Providing 24-hour emergency site access via helicopter would require a range of specific installations, equipment, planning and permitting. A key factor in the occurrence of accidents on drilling programs is the level of worker experience, the quality of supervision and worker attitude. Significant reduction in the likelihood of worker injury on a heliportable drilling program can be achieved by ensuring high levels of experience and training for all rig personnel.

At present, the probability of an uncontrolled blow-out during drilling appears to be in the range of 0.3 to 0.6 blow-outs/1,000 wells. The cause of most blow-outs during exploration drilling programs is human error. The potential to significantly reduce the risk of a blow-out on a heliportable drilling program could be achieved by requiring use of only highly trained and experienced crews and ensuring the well site has been stocked with adequate drilling supplies. In order to minimize the environmental risk associated with a blow-out at a heliportable well site, the site needs to be planned in consideration of blow-out response and management. In addition, risk could further be reduced by maintaining a reserve of at least three or more pieces of heavy equipment onsite (*e.g.*, one bulldozer, one crane and one back hoe). A protocol and arrangement for access to other heavy equipment and transport capability, at least during more critical phases of the drilling program, should also be in place.

During a blow-out where there is a perceived risk to human life, drilling crews are typically evacuated on foot outside of the immediate hazard zone via pre-determined routes. For a conventional road accessed well, the access road is not relied on as the primary emergency escape route but is instead among the alternatives, depending on conditions at the time of the blow-out. With provision of adequately planned emergency escape routes (*e.g.*, via foot or hand-cleared ATV routes), temporary accommodations and an air trailer or trailers (for sour gas wells), an equivalent level of worker and equipment protection as occurs at road accessed sites, can be achieved at a heliportable sour gas well.

In the event of a significant uncontrolled sour gas release where there is a perceived hazard to workers, the rig is typically ignited after a short period in order to eliminate the sour gas hazard and facilitate well control operations. In properly managed situations, the hazard associated with a sour gas blow-out at a heliportable drill site would be of short duration (*e.g.*, minutes) and the availability of long distance road access would be of no clear necessity. In rare cases where large volumes of sour water are being produced, rig ignition may be delayed until such time as liquid streams can be diverted to a separator and gas ignition achieved. More prolonged use of emergency air equipment may be required in these circumstances in the immediate vicinity of the well site.

The science and techniques used for blow-out control have advanced significantly in recent years such that more immediate well control or partial control (where the flow can be directed) can be achieved more rapidly by capping the existing well bore than by drilling a relief well. Controlling most blow-outs can be achieved within a period of days, or in some cases weeks. Once the flow is stopped by capping, a second rig can be deployed in a less urgent fashion. All of the equipment used for well capping can be maintained on a heliportable site or quickly flown in for this purpose. In rare cases where the drill casing cannot be reached by excavation, a relief rig may still be required. Where a relief rig is deemed necessary for control of a blow-out, conventionally accessed drilling sites are at an advantage since the pool of available relief rigs is in theory much larger and these can be delivered onsite and assembled in a more timely fashion. For a heliportable well site, providing relief well capability would require prior arrangement for a heliportable drilling rig and paying standby charges or relying on assumed availability. Services of heavy-lift helicopter transport for a contingency relief drilling rig are generally available on short notice. An alternate scenario involves construction of a conventional access road for relief well mobilization and incurring the associated environmental impacts.

A major concern during a blow-out is the release of liquids. Release volumes of salt water and other liquids can at times be large. Conventional road accessed well sites afford the opportunity to rapidly mobilize heavy equipment and to transport large volumes of liquids. This ability is not practically achievable on a heliportable well site but could be managed by contingency planning, proper site selection, ensuring proper site drainage, as well as having a reserve of heavy equipment onsite or readily available for transport and assembly.

It is recommended that if heliportable drilling is ultimately promoted in the MK, a set of best practices should be developed which would focus on the needs for overall heliportable planning and coordination, training requirements, supervision, environmental protection, blow-out prevention and response. The influence of underbalanced drilling on blow-out risk should be further evaluated. The potential applicability of emerging technology such as "casing drilling" to significantly extend the depth range and possible safety of heliportable rigs should be further monitored and explored. These undertakings should be collaboratively pursued through the Canadian Petroleum Safety Council or equivalent provincial body.

Economic Report

Previous heliportable feasibility evaluations, while recognizing the potential environmental advantages of heliportable drilling, have frequently identified the direct incremental cost of heliportable drilling as a key factor limiting the feasibility of heliportable drilling. The Economic Report identifies and explores a number of key cost factors associated with conventional versus heliportable drilling and draws on previous heliportable cost analyses conducted in northern BC. The major cost differences identified were associated with access. While total road costs and helicopter costs tend to go up with increasing distance, road related costs are much more variable due to specific terrain differences, assessment and engineering requirements, reclamation challenges from site to site and the potential significant influence of short-term and seasonal weather patterns. For heliportable drilling there is a relatively linear relationship between distance and cost. The influence of weather on heliportable transport cost is projected to be minor.

Depending on the site conditions, heliportable drilling appears to have greater potential to be more expensive than conventional surface access for programs requiring relatively short access but less expensive, considering direct costs alone, relative to longer more complex roads through sensitive terrain. The primary costs associated with heliportable drilling include those associated with potential foreign rig mobilization, mobilization of the drilling rig, drilling supplies and camp from the staging area, helicopter support during drilling, contingency stockpiling and potentially water supply.

Heliportable rigs, like conventional rigs, range in cost depending on their drilling depth capability. Mobilizing a medium to large heliportable local rig may cost in the vicinity of $500,000, while mobilizing the same rig from a foreign location to northern BC could be in the range of $1.5 million to $2.5 million CDN. At the time of this review, there were four heliportable rigs in Western Canada all depth rated to 3,400 m.

A conventional drilling rig can be converted to a heliportable rig, at a cost ranging from $2 million to $5 million CDN and would take perhaps four to six months. Rough cost estimates to custom build a heliportable rig were variable and dependent on whether the rig was built in Canada or the US. These rough estimates ranged from $12 million CDN to $20 million US. Costs to build a heliportable rig capable of drilling to 3,400 m were estimated at $6 million to $7 million CDN. Construction time to build a deep-rated heliportable rig was estimated to take approximately 8 to 10 months. While redesigning a conventional rig appears to be more cost effective than building a new heliportable rig, this approach is disfavored by the drilling contractors as it requires taking a conventional rig out of normal service and has potential to result in a less purpose-built design integrity.

Although the risk of a blow-out is very low, in most cases in the event of a blow-out, well control at a heliportable well site will be more efficiently and cost effectively controlled by capping rather than the use of a relief rig. In rare cases where a relief rig is required, this can be achieved either by mobilizing any available heliportable rigs with sufficient depth capability or by constructing a new access road to the well site and mobilizing a conventional rig. Substantial additional costs can be expected in either case. Costs associated with any requirement to guarantee a designated relief well throughout the drilling program would result in a further substantial cost that would have implications for overall cost and projected returns on investment. Blow-outs result in significantly increased costs for both conventional and heliportable exploration drilling programs. For a heliportable well site, the monetary costs can be expected to be substantially greater than with a conventional blow-out due to the potential need to fly in any additional heavy equipment and other blow-out containment supplies not stockpiled onsite. This cost can be substantially reduced by proper contingency planning and retention of some heavy equipment onsite.

If company policy or regulators required 24-hour well site access, helicopters, crews and landing areas would have to be set up for Night Visual Flying Rules and possibly a full Instrument Landing System. A 24-hour, on demand, helicopter serviced operation would require additional items and costs and add perhaps close to $1 million to the cost of a 90-day heliportable drilling program.

Weather delays encountered during either a conventional or heliportable operation can be expected to increase costs by incurring standby charges and/or by delaying completion of critical phases of the project. Weather delays associated with a conventional road accessed well site can occur in the summer as a result of rain, as a result of delays in freeze-up and early spring thaw. Weather delays associated with a heliportable well site occur as a result of high wind, low cloud and fog cover and icing conditions. Weather is expected to have greater cost implications for conventional road accessed well sites than heliportable well sites.

A primary cost difference between conventional road accessed drilling and heliportable drilling is that the heliportable option does not require construction or reclamation beyond the well site, camp and staging area. While impacts and reclamation costs can be significantly reduced with low impact winter roads, opportunities to carry out this practice in the MK are very site-specific. In general, road reclamation costs are expected to be equivalent to road construction costs.

Site-specific and judicious promotion of heliportable drilling within the MK has the potential to result in more sustainable long-term economic benefit and employment with a reduction in environmental and related social costs. Integration of heliportable technology into the petroleum sector in northeastern BC may somewhat diversify and strengthen the base for local contracting and joint ventures.

Recommendations include: developing a clear policy with regard to the use of heliportable drilling in the MK; preparing site specific guidelines which are identified prior to a land posting; and providing financial incentives to the petroleum industry where commitments are made to use heliportable drilling.

Synthesis, Conclusions and Recommendations

When considering the range of issues associated with heliportable exploration drilling, it is clear the government must balance a broader set of social and economic costs and benefits associated with heliportable drilling compared with the petroleum industry. Factors which affect the public and First Nation's acceptance of oil and gas development can still have significant cost implications for the industry through either delays required for consultation and/or pressure for activity exclusion or other restrictions. A range of cost and benefit variables associated with heliportable exploration drilling are summarized. Depending on the variable, the cost or benefit may be more immediately felt by the government, the public, industry or shared by all groups.

Heliportable drilling relative to conventional road access must be compared, on a site-specific basis, with whatever least impact, surface access alternative a given prospect may present. For example, a site may be readily accessed by an existing seismic line, road or snow road, and in doing so, must be compared to the "costs" associated with a heliportable approach (as well as some of the benefits).

Forcing a company to assume large incremental "costs" for marginal environmental or social benefit will create a general disincentive for exploration where the potential return on investment is perceived as low.

Based on review of the various costs and benefits, six *Critical Factors* were identified that are believed to represent the most important issues when considering the site-specific feasibility of heliportable drilling. These are: environmental sensitivity; availability of low impact alternatives; helicopter site risk; capital cost; blow-out risk and worker safety; and presence of sour gas.

Environmental sensitivity, availability of low impact alternatives and helicopter site risk have a direct bearing on capital cost and will vary widely from site to site. Industry's demonstrated ability to manage blow-out risk and to operate safely in sour gas environments, combined with the probable level of planning and expertise, which would be applied to heliportable drilling, suggests that blow-out risk and presence of sour gas, should be less critical considerations concerning heliportable drilling feasibility. These two factors are also relatively independent of cost. In the absence of adequate contingency planning, however, it is clear that a blow-out, involving high volume uncontrolled liquids release would have substantially greater cost implications on a heliportable project.

At least three approaches to decision making can be used in regard to assessing heliportable feasibility: formal quantitative cost-benefit analysis; quantitative ranking of individual sites or areas; and/or through a collaborative decision making process. None of these approaches are necessarily exclusive. Applying rankings and scores to the identified *Critical Factors* in terms of whether an individual site or region within the MK is more or less suitable for heliportable drilling can be used to systematically evaluate the overall feasibility of the site or area for heliportable drilling. It also illustrates the sensitivity of the evaluation to the various factors and the importance assigned to them. This approach is used on two hypothetical examples modeled after probable scenarios likely to be encountered in the MK.

In a general sense, there does not appear to be any basis for concluding that heliportable drilling in the MK is not feasible and should not be included in the range of low impact options acceptable to the MK resource managers. There will, however, be site-specific circumstances where it is relatively more or less feasible. Regulators could decide whether they were inclined to require heliportable drilling by location, by circumstance or to let the company decide.

Within the MK, it is clear there are likely to be locations proposed for drilling which will have conventional initial access "costs" exceeding that of heliportable access, where the environmental consequences of exploration roads will be high and where the potential economic reward of a prospect may be high. Heliportable drilling would appear to be a feasible, environmentally sound and safe approach to petroleum exploration in these cases.

In cases where estimated costs for heliportable drilling significantly exceed conventional surface access approaches (with expected emphasis on low impact approaches), the feasibility will depend on industry's valuation of the economic risks, the extent to which these can be offset by incentives and the government and industry's confidence in the proponent's ability to adequately manage environmental and human safety risks. From the information examined, there appears to be reasonably compelling evidence to suggest that these latter factors can be managed to a level at least equivalent to that associated with conventional surface accessed well sites.

A summary of the recommendations are as follows:

1. Heliportable drilling should be included in the range of land use management tools used by MK resource managers.
2. Developing a clear policy and guidelines with regard to the use of heliportable drilling in the MK should be undertaken in order to reduce uncertainty within the industry and among resource users prior to land posting.

3. In the event a policy decision is made which endorses the site-specific application of heliportable drilling, a set of best practices should be developed.
4. Consideration should be given to conducting an initial heliportable drill as a pilot study to facilitate the implementation and to promote refinement of any subsequent guidelines and procedures.
5. Identifying and mapping areas where the potential for low impact alternatives exist, as well as areas which may be more suited to helicopter access only should be considered.
6. Consideration should be given to increasing the feasibility of heliportable drilling by providing financial incentives to the petroleum industry where commitments are made to use this access approach.
7. The practicality and economics of heliportable only

access for the operations phase of oil and gas development should be explored further.

TABLE OF CONTENTS

Background on Heliportable Drilling and Regulatory and Policy Review **Page**

EXECUTIVE SUMMARY i
1.0 INTRODUCTION 1
  1.1 Project Background and Scope 1
  1.2 Methods 2
  1.3 Transportation Services in the BC Oil and Gas Industry 2
    1.3.1 Heliportable Drilling 3
2.0 PREVIOUS HELIPORTABLE EVALUATIONS IN NORTHEASTERN BC 5
  2.1 Amoco Canada Petroleum Company Ltd. (Beattie Peaks, 1991) 5
  2.2 Talisman Energy (PCP Falls, 1994) 5
  2.3 Imperial Oil Limited (Belcourt Creek, 1995) 6
  2.4 Murphy Oil Company Ltd. (Sikanni, 1996) 6
  2.5 Husky Oil Operations Ltd. (Sikanni, 1996) 7
  2.6 Murphy Oil Company Ltd. (Chicken Creek, 1999) 7
  2.7 Ricks Nova Scotia Co. (Ladyfern, 2000) 8
  2.8 Marathon Canada Ltd. (Koller Creek, 2001) 9
  2.9 Ministry of Energy, Mines and Petroleum Resources 1995 Study 10
3.0 CONTEMPORARY PERSPECTIVES ON HELIPORTABLE DRILLING 11
  3.1 Oil and Gas Industry 11
  3.2 Helicopter Companies 11
  3.3 Drilling Companies 12
  3.4 Provincial Government Staff 13
4.0 REGULATORY AND POLICY REVIEW 14
  4.1 Petroleum and Natural Gas Act 14
    4.1.1 Drilling and Production Regulation 14
  4.2 Workers' Compensation Act 14
    4.2.1 The Occupational Health and Safety Regulation 15
  4.3 Oil and Gas Commission Act 15
  4.4 Muskwa-Kechika Management Area Act 16
  4.5 BC Oil and Gas Commission Maximum Disturbance Review Criteria Code and Guideline 16
  4.6 Conclusion 16
5.0 REFERENCES 17
  5.1 Personal Communications 17
  5.2 Literature Cited 17

LIST OF APPENDICES

Appendix A Example of Questionnaire and Responses 19

LIST OF FIGURES

Figure 1 Muskwa-Kechika Management Area 4

Environmental Report **Page**

EXECUTIVE SUMMARY i

1.0 INTRODUCTION 1
- 1.1 Management within the Muskwa-Kechika Management Area 1
  - 1.1.1 Protected Areas, Parks and Ecological Reserves 3
  - 1.1.2 Access Management 3

2.0 ENVIRONMENTAL SETTING AND ITS SIGNIFICANCE 6
- 2.1 Topography 6
- 2.2 Hydrocarbon Geology and the Occurrence of Sour Gas 7
- 2.3 Climatic Conditions 11
  - 2.3.1 Temperature 11
  - 2.3.2 Fog/Low Cloud Cover 14
  - 2.3.3 Precipitation and Icing 15
  - 2.3.4 Wind 20
  - 2.3.5 Heliportable Well Site Location and its Relationship to Climatic Concerns 23
- 2.4 Day Length 24
- 2.5 Vegetation 25
- 2.6 Fish and Aquatic Ecosystems 27
- 2.7 Critical Wildlife Habitat 27
- 2.8 Land Use 31
  - 2.8.1 Guide Outfitting and Trapping 31
  - 2.8.2 Backcountry Recreation 33
  - 2.8.3 Forestry 34
  - 2.8.4 Mining 34

3.0 IMPACTS OF ROADS 35
- 3.1 Impacts on Fish and Aquatic Ecosystems 35
- 3.2 Impacts on Wildlife 36
  - 3.2.1 Moose 36
  - 3.2.2 Elk 36
  - 3.2.3 Caribou 37
  - 3.2.4 Mountain Sheep and Goats 38
  - 3.2.5 Grizzly Bear 38
  - 3.2.6 Birds 39
  - 3.2.7 Road Management Policy in the MK and Wildlife 39

4.0 IMPACTS OF HELICOPTERS 40
- 4.1 Impacts on Wildlife 40
- 4.2 Helicopter Flight Guidelines 44
- 4.3 Impacts on Land Use 45

5.0 COMPARATIVE EVALUATION OF IMPACTS THROUGH THE LIFE CYCLE OF OIL AND GAS EXPLORATION AND DEVELOPMENT 46
- 5.1 Seismic Program 46
  - 5.1.1 Conventional Seismic 46
  - 5.1.2 Heliportable Seismic 46
- 5.2 Exploration Drilling 47
  - 5.2.1 Conventional Exploration Drilling 47
  - 5.2.2 Heliportable Exploration Drilling 48
- 5.3 Field Development, Production and Operations 49
  - 5.3.1 Conventional Field Development, Production and Operations 49
  - 5.3.2 Heliportable Field Development, Production and Operations 50
- 5.4 Abandonment and Reclamation 50
- 5.5 Summary of the Environmental Impacts Through the Life Cycle 50

6.0 MITIGATION MEASURES 53
7.0 CONCLUSION 56
8.0 RECOMMENDATIONS 57
9.0 REFERENCES 58
  9.1 Personal Communications 58
  9.2 Literature Cited 58

LIST OF FIGURES

Figure 1 Environmental Factors Influencing Heliportable Drilling 1
Figure 2 Muskwa-Kechika Management Area 2
Figure 3 Land and Resource Management Zones 4
Figure 4 Parks and Protected Areas and Designated Access Routes 5
Figure 5 Terrain Slope Classification and Elevation 8
Figure 6 Distribution of Hydrocarbon Formations 9
Figure 7 Mean Monthly Temperatures (°C) for Muncho Lake 1970-2000 12
Figure 8 Mean Daily Temperature in Sikanni Area, 1995 (adapted from Sikanni Chief Weather Station) 12
Figure 9 Mean Monthly Precipitation for Muncho Lake 1970 to 2000 16
Figure 10 Total Monthly Precipitation in Sikanni Chief Area, 1995 (adapted from Sikanni Chief Weather Station) 16
Figure 11 Mean Monthly Wind Speed in Sikanni Chief Area, 1995 (adapted from Sikanni Chief Weather Station) 20
Figure 12 Wind Energy Resource Map 22
Figure 13 Vegetation Communities 26
Figure 14 Habitat Suitability of Stone's Sheep 29
Figure 15 Habitat Suitability of Mountain Goat 30
Figure 16 Guide Outfitting and Trapping Boundaries 32

LIST OF TABLES

Table 1 Average Monthly Temperatures (°C) for Selected Periods at Muncho Lake 13
Table 2 Averages and Extremes Data on Frost Events in the Muskwa-Kechika Management Area 13
Table 3 Average Monthly Total Rainfall, Total Snowfall and Total Precipitation Values for Muncho Lake for Selected Periods 17
Table 4 Day Length at Muncho Lake 24
Table 5 Summary of Research on the Impacts of Helicopter and Aircraft on Large Mammals 41
Table 6 Flight Guidelines in the Besa Prophet Management Area 44
Table 7 Summary of Environmental Impacts During Life Cycle 51
Table 8 Mitigation for Road-Based Exploration Programs 53
Table 9 Mitigation for Helicopter-Based Exploration Programs 55

LIST OF PLATES

Plate 1 Example of side cast fill. 7
Plate 2 Example of "socked-in" conditions with heavy fog and low cloud cover. 17
Plate 3 View of Chicken Creek valley and low impact ice road to winter exploration well site. (Photo courtesy of Kaizen Environmental Services Inc.) 19
Plate 4 View along Chicken Creek in summer following construction of low impact ice road and well site. (Photo courtesy of W. Sawchuk). 19
Plate 5 Woodland caribou along access road 37
Plate 6 View of mountain goats on steep south-facing slope. 38

Technical Report **Page**

EXECUTIVE SUMMARY ... i

1.0 INTRODUCTION ... 1

2.0 DRILLING RIG REQUIREMENTS AND AVAILABILITY ... 2
  2.1 Heliportable Drilling Rigs ... 2
  2.2 Conventional Rigs ... 3
    2.2.1 Conclusion ... 3

3.0 OTHER SERVICES AND EQUIPMENT ... 4
  3.1 Supervision and Crew Requirements ... 4
  3.2 Drilling Mud, Tubulars and Related Consumables ... 4
  3.3 Water and Water Well Rigs ... 5
  3.4 Sumps and Tanks ... 5
  3.5 Cementing ... 5
  3.6 Nitrogen Services ... 6
  3.7 Completions and Service Rigs ... 6
  3.8 Wireline Services ... 6
  3.9 Coiled Tubing ... 7
  3.10 Fracturing ... 7
  3.11 Drilling Camp ... 7
  3.12 Conclusion ... 8

4.0 HEAVY-LIFT HELICOPTER AVAILABILITY AND CAPABILITY ... 9
  4.1 Availability and Capability of Heavy Lift Helicopters ... 9
  4.2 Conclusion ... 10

5.0 HELICOPTER DRILLING SUPPORT SERVICES ... 11
  5.1 Conclusion ... 11

6.0 WELL SITE CONSTRUCTION AND RECLAMATION ... 12
  6.1 Conventional ... 12
  6.2 Heliportable ... 12
  6.3 Conclusion ... 13

7.0 PLANNING AND TIMING CONSIDERATIONS ... 14
  7.1 Planning and Approvals ... 14
  7.2 Scheduling ... 14
  7.3 Heliportable Lease and Staging Area Preparation ... 16
  7.4 Drilling Rig Mobilization and Demobilization ... 16
  7.5 Other Timing Considerations ... 17
  7.6 Conclusion ... 17

8.0 WELL CONTROL AND SOUR GAS BLOW-OUTS ... 18
  8.1 Probability of Occurrence ... 18
  8.2 Blow-out Prevention and Risk Minimization ... 19
  8.3 Blow-out Response ... 20
    8.3.1 Site Evacuation ... 22
    8.3.2 Management of Released Sour Gas and Liquids ... 22
  8.4 Blow-out Control Using Relief Rigs ... 24
  8.5 Underbalanced Drilling ... 24
  8.6 Conclusion ... 25

9.0 24-HOUR EMERGENCY MEDICAL RESPONSE ... 26
  9.1 Conclusion ... 27

10.0 WORKERS' COMPENSATION BOARD OF BC ... 28
  10.1 Conclusion ... 28

11.0 PIPELINE AND FACILITY CONSTRUCTION 29
  11.1 Conclusion 29
12.0 OPERATIONS 30
  12.1 Conclusion 30
13.0 Abandonment 31
14.0 RECOMMENDATIONS 32
15.0 REFERENCES 33
  15.1 Personal Communications 33
  15.2 Literature Cited 34

LIST OF APPENDICES

Appendix A Type and Availability of Heliportable Rigs 35
Appendix B Capability and Availability of Heavy and Medium Lift Helicopters in North America 36

LIST OF FIGURES

Figure 1 Technical Factors Influencing Heliportable Drilling 1

LIST OF TABLES

Table 1 Tasks Associated with a Heliportable Drilling Program 15
Table 2 Drilling Blow-Outs in Alberta and British Columbia 1992-2001 18

Economic Report **Page**

EXECUTIVE SUMMARY i

1.0 INTRODUCTION 1

2.0 PREVIOUS HELIPORTABLE VS. CONVENTIONAL COST COMPARISONS CONDUCTED IN NORTHEASTERN BC 2

3.0 GENERIC CASE STUDY COMPARISON OF PROBABLE HELIPORTABLE VS. CONVENTIONAL COSTS FOR THE MUSKWA-KECHIKA 8

4.0 COST OF HELIPORTABLE DRILLING RIGS 10
- 4.1 Conversion of Conventional Rigs and Custom Designed Heliportable Rigs 10
- 4.2 Relief Drilling Rig and Blow-out Control Costs 12

5.0 HELICOPTER RATES 13
- 5.1 Helicopter Planning and Logistics 14
- 5.2 24-Hour Operation 14

6.0 OTHER HELIPORTABLE DRILLING COST CONSIDERATIONS 15
- 6.1 Stockpiling 15
- 6.2 Rig and Camp Water 15
- 6.3 Casing Drilling 15
- 6.4 First Aid Requirements 16
- 6.5 Insurance 16

7.0 POTENTIAL COSTS RELATED TO WEATHER DELAYS, SEASONAL CONDITIONS AND BLOW-OUTS 17
- 7.1 Weather Delays and Seasonal Conditions 17

8.0 RECLAMATION COST CONSIDERATIONS 18

9.0 INVESTMENT OPPORTUNITIES, JOB CREATION AND GOVERNMENT REVENUE 19

10.0 CONCLUSION 22

11.0 RECOMMENDATIONS 23

12.0 REFERENCES 24
- 12.1 Personal Communications 24
- 12.2 Literature Cited 24

LIST OF APPENDICES

Appendix A Cost Analysis From Previous Projects 26

LIST OF FIGURES

Figure 1 Cost Factors Influencing Heliportable Economic Feasibility 1
Figure 2A Comparison of Road-Based Drilling and Helicopter-Based Drilling Cost Estimates for Various Exploration Drilling Projects in Mountainous Areas of Northeastern BC 6
Figure 2B Comparison of Road Construction and Helicopter Transportation Cost Estimates for Various Exploration Drilling Projects in Mountainous Areas of Northeastern BC 7

LIST OF TABLES

Table 1 Conventional vs. Heliportable Cost Comparisons from Previous Projects in Northeastern BC 3
Table 2 Generic Conventional vs. Heliportable Cost Comparison Scenarios 9
Table 3 2002 Heliportable Drilling Rig Rates and Mobilization Fees 11
Table 4 Helicopter Rates 13
Table 5 Potential Economic Costs and Benefits of Heliportable Drilling in the MK 20

Synthesis, Conclusions and Recommendations **Page**

EXECUTIVE SUMMARY i
1.0 INTRODUCTION 1
2.0 COST BENEFIT ANALYSIS 2
  2.1 Qualitative Cost-Benefit Comparison 2
  2.2 Other Considerations 8
3.0 CRITICAL FACTORS AND DECISION MAKING 9
  3.1 Decision Making 11
  3.2 Heliportable Drilling Suitability and Critical Factors 12
    3.2.1 Environmental Sensitivity 12
    3.2.2 Availability of Low Impact Alternatives 13
    3.2.3 Helicopter Risk 13
    3.2.4 Capital Cost 14
    3.2.5 Blow-Out Risk and Worker Safety 15
    3.2.6 Sour Gas 16
4.0 DECISION MATRIX 17
5.0 CONCLUSION 19
6.0 RECOMMENDATIONS 20
7.0 REFERENCES 22

LIST OF TABLES

Table 1 Cost Benefit Analysis of Heliportable Drilling in the MK 4
Table 2 Critical Factors and Considerations for Heliportable Drilling 10
Table 3 Decision Matrix 18

MUSKWA-KECHIKA MANAGEMENT AREA HELIPORTABLE DRILLING FEASIBILITY STUDY

BACKGROUND ON HELIPORTABLE DRILLING AND REGULATORY AND POLICY REVIEW

Prepared for:

BC Ministry of Sustainable
Resource Management,
Muskwa-Kechika
Advisory Board
and the
BC Oil and Gas Commission

Prepared by:

Randal Glaholt and Lois Pittaway

TERA Environmental Consultants
Suite 1100, 815 - 8th Avenue S.W.
Calgary, Alberta T2P 3P2

Brian Churchill

Chillborne Environmental Services
SS2 Site 22 Comp 23
Fort St. John, BC V1J 4M7

Harris Wheeler
AAEA Ltd.
Charlie Lake, BC V0C 1H0

June 2002
2555

EXECUTIVE SUMMARY

The potential use of helicopter supported drilling (heliportable drilling) for oil and gas exploration in environmentally sensitive areas of northeastern British Columbia has been actively debated and considered for many years. It has thus far been rejected by either the proponent and/or the government based on concerns over safety, blow out control, sour gas, cost, scheduling constraints, technical limitations, lack of experience and availability of alternatives.

Despite these concerns, there remains a strong interest in the potential application of heliportable drilling within environmentally sensitive areas in BC. This interest has been fueled in part by the awareness of heliportable drilling being successfully carried out elsewhere in the world, a belief that the concerns raised by heliportable drilling can ultimately be addressed and a concern that the significant ecological and social values of the MK are deserving of exceptional protective measures where industrial development is to be allowed. The goal of the present study was to examine the costs, benefits and feasibility of helicopter-supported exploration drilling in environmentally sensitive areas with particular consideration of the operating conditions found in the foothills and mountains of the northwestern portion of the Western Canadian Sedimentary Basin.

Interviews conducted for the purpose of this study revealed that industry's current concerns in regard to heliportable drilling are related to economics, safety and the availability of suitable equipment.

Existing legislation and regulations that are relevant to the question of helicopter-supported oil and gas operations were reviewed. Specifically the *Petroleum and Natural Gas Act* and regulations, the BC Oil and Gas Handbook, the *Workers' Compensation Act* and companion Occupational Health and Safety Regulations, the *Muskwa-Kechika Management Area Act* and the Maximum Disturbance Review Criteria Code and Guideline. Based on this review and discussions with the Workers' Compensation Board of BC and the BC Oil and Gas Commission, there are no significant regulatory constraints to heliportable drilling provided in the acts and regulations.

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY i

1.0 INTRODUCTION 1
- 1.1 Project Background and Scope 1
- 1.2 Methods 2
- 1.3 Transportation Services in the BC Oil and Gas Industry 2
  - 1.3.1 Heliportable Drilling 3

2.0 PREVIOUS HELIPORTABLE EVALUATIONS IN NORTHEASTERN BC 5
- 2.1 Amoco Canada Petroleum Company Ltd. (Beattie Peaks, 1991) 5
- 2.2 Talisman Energy (PCP Falls, 1994) 5
- 2.3 Imperial Oil Limited (Belcourt Creek, 1995) 6
- 2.4 Murphy Oil Company Ltd. (Sikanni, 1996) 6
- 2.5 Husky Oil Operations Ltd. (Sikanni, 1996) 7
- 2.6 Murphy Oil Company Ltd. (Chicken Creek, 1999) 7
- 2.7 Ricks Nova Scotia Co. (Ladyfern, 2000) 8
- 2.8 Marathon Canada Ltd. (Koller Creek, 2001) 9
- 2.9 Ministry of Energy, Mines and Petroleum Resources 1995 Study 10

3.0 CONTEMPORARY PERSPECTIVES ON HELIPORTABLE DRILLING 11
- 3.1 Oil and Gas Industry 11
- 3.2 Helicopter Companies 11
- 3.3 Drilling Companies 12
- 3.4 Provincial Government Staff 13

4.0 REGULATORY AND POLICY REVIEW 14
- 4.1 Petroleum and Natural Gas Act 14
  - 4.1.1 Drilling and Production Regulation 14
- 4.2 Workers' Compensation Act 14
  - 4.2.1 The Occupational Health and Safety Regulation 15
- 4.3 Oil and Gas Commission Act 15
- 4.4 Muskwa-Kechika Management Area Act 16
- 4.5 BC Oil and Gas Commission Maximum Disturbance Review Criteria Code and Guideline 16
- 4.6 Conclusion 16

5.0 REFERENCES 17
- 5.1 Personal Communications 17
- 5.2 Literature Cited 17

LIST OF APPENDICES

Appendix A Example of Questionnaire and Responses 19

LIST OF FIGURES

Figure 1 Muskwa-Kechika Management Area 4

1.0 INTRODUCTION

1.1 Project Background and Scope

The potential use of helicopter supported drilling (heliportable drilling) for oil and gas exploration in environmentally sensitive areas of northeastern British Columbia has been actively debated and considered for many years. In cases where it has been considered or applied for it has thus far been rejected by either the proponent and/or the government. The reasons for this have been related to concerns over safety, blow-out control, sour gas, cost, scheduling constraints, technical limitations, lack of experience and availability of alternatives. Despite these concerns, there remains a strong interest in the potential application of heliportable drilling within environmentally sensitive areas in BC such as the Muskwa-Kechika Management Area (herein referred to as the MK) (Figure 1). The Ministry of Sustainable Resource Management, Resource Planning Division, in partnership with the Muskwa Kechika Advisory Board and BC Oil and Gas Commission determined that a heliportable drilling feasibility study would assist them in satisfying the objectives of the *Muskwa-Kechika Management Area Act*. The Ministry of Sustainable Resource Management, Resource Planning Division awarded a contract to TERA Environmental Consultants to undertake the following study.

The goal of the study was to examine the costs, benefits and feasibility of helicopter-supported exploration drilling in environmentally sensitive areas with particular consideration of the operating conditions found in the foothills and mountains of the northwestern portion of the Western Canadian Sedimentary Basin.

The terms of reference for the study specifically required completion of three linked reports exploring the environmental considerations, technical feasibility and economics of heliportable drilling. The Environmental Report compares and discusses the relative impacts of conventional road access and heliportable drilling on fish, wildlife, vegetation, land use and the landscape aesthetic. While this environmental comparison focuses on the exploration phase, consideration is also given to the full life cycle of oil and gas exploration and development. The Technical Report explores whether or not the range of transportation needs associated with well site construction, rig mobilization, drilling and emergency response can be physically and practically met using helicopters as the primary means of site access. The Economic Report evaluates the cost implications of environmentally sound and technically feasible heliportable drilling on exploration economics, investment opportunities, job creation and government revenues. The study concludes with a synthesis of these three reports, including a cost-benefit comparison, suggestions for a decision making process and a series of recommendations.

The subsections which follow provide further background on transportation in the oil and gas industry in BC, the occurrence of heliportable drilling elsewhere in other jurisdictions, previous heliportable drilling evaluations in BC, contemporary perspectives on heliportable drilling and a review of relevant regulations and policy.

1.2 Methods

The overall study was undertaken using a combination of structured and informal consultation and literature reviews. A broad range of individuals with technical experience in both conventional and heliportable drilling were interviewed. A record of all parties interviewed and their summary comments are presented in Appendix A. The literature reviews included a review of previous research conducted on heliportable drilling and a consolidation of relevant information from previous heliportable evaluations in northeastern BC. The information is presented using comparative tables to facilitate understanding of the differences and similarities between conventional and heliportable approaches.

1.3 Transportation Services in the BC Oil and Gas Industry

The oil and gas industry in BC has evolved based on ground transportation, starting with horse and mule pack trains and boats for transport of early drilling efforts. In the 1960s and 1970s, drilling in remote areas was often partially or totally supported by fixed wing aircraft. While often initially accessed by winter roads and tracked vehicles, a number of developments (*e.g.*, Beaver River, Helmut) relied very heavily on fixed wing aircraft support, both during the winter season and throughout the year for an extended drilling season and for production. The industry has responded to increased pressure to reduce it's impacts through a number of means including directional drilling, more diligent use of existing linear disturbances, snow making for the creation of snow roads, use of matting, more intensive planning and consideration of other alternatives such as heliportable drilling.

In BC, helicopters have been extensively used for personnel support and supply for drilling operations since the 1950s. However, the capacity to mobilize full size projects with helicopters was not readily available until the 1980s when military heavy lift equipment helicopters became available for civilian use. There has been interest in assessing helicopter transportation to address some environmental, cost and logistical issues associated with oil and gas activity for more than a decade.

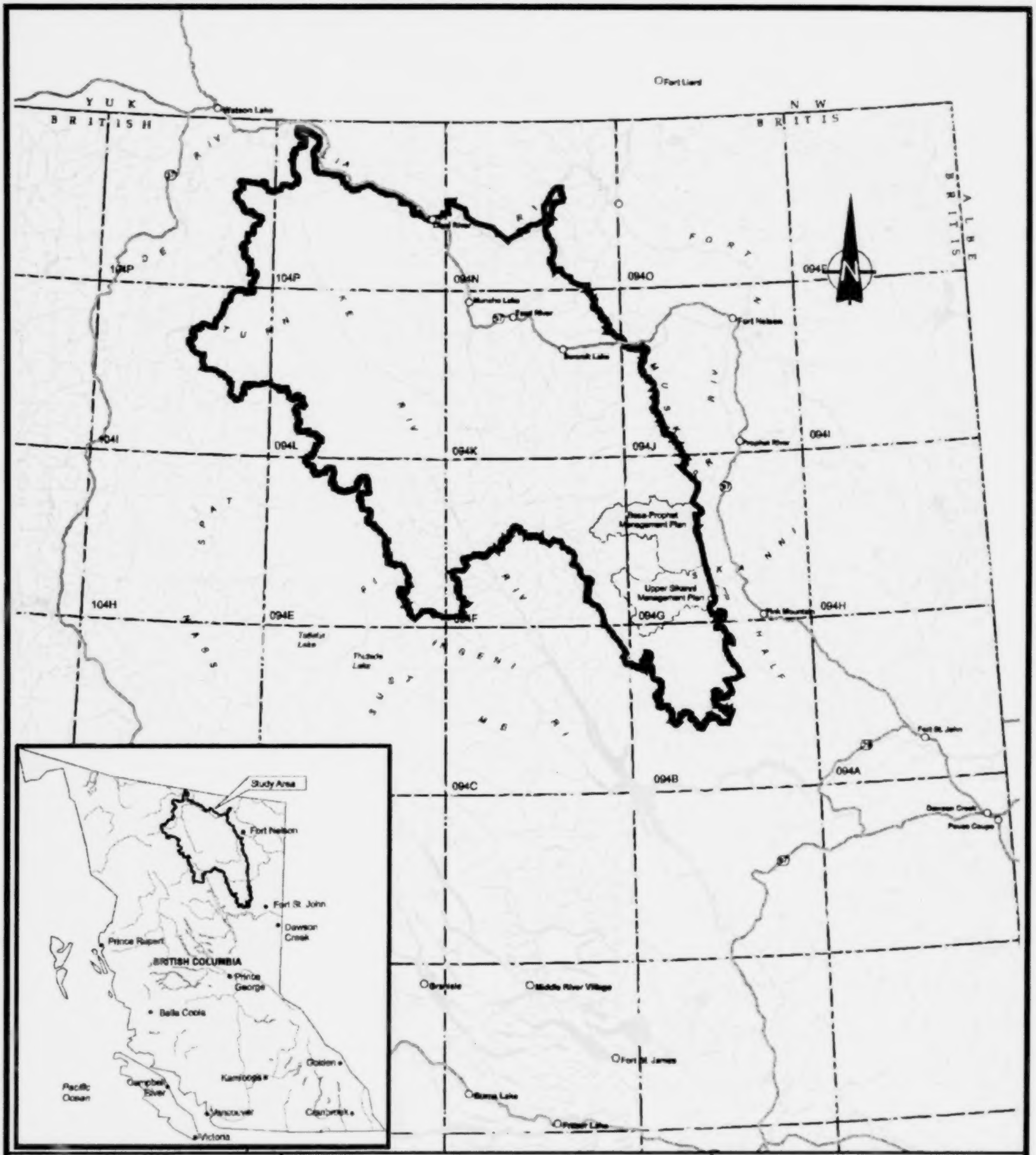
For heliportable drilling to be functionally equivalent to conventional road accessed drilling, it needs to efficiently replace some or all of the services provided by surface access. Surface access currently facilitates the following:

- heavy equipment mobilization for well site construction;
- hauling of the drilling rig, rig shacks, tanks, drilling supplies, water (if unavailable onsite), sump wastes (if a remote sump is used);
- hauling of an emergency relief rig if required;
- emergency access to and from the well site;
- pipelining;
- ongoing well operations and servicing; and
- facilitating other resource use activities (*e.g.*, logging, recreation access).

1.3.1 Heliportable Drilling

Heliportable exploration drilling has been undertaken by numerous companies internationally, and to a lesser extent in North America for socio-economic and environmental reasons. Although the total number of heliportable wells drilled internationally has not been determined, Columbia Helicopters Inc. of Portland, Oregon has been involved in over 150 heliportable drilling programs (Peterson pers. comm.). Within North America, relatively few heliportable exploration drilling programs have been undertaken. In the 1970s, Shell Canada completed several wells in the Mackenzie Delta in the 3,000 m plus range using "heli-hoist rigs" provided by Ideco Drilling, a subsidiary of Parker Drilling (Hunley pers. comm.). Sikorsky S-58T and Sikorsky S-61 helicopters were used to move both rigs and camps in the Mackenzie Delta area. All fuel, cement, pipe and other supplies were flown in by medium lift helicopters. Subsequent to that, Marathon Canada Limited conducted a heliportable drill in Cody, Wyoming in 1985 and Chevron USA Inc. completed a well near Teton National Park in Wyoming in 1992 (US Forest Service and Bureau of Land Management 1992). Both locations were considered to have potential for high concentrations of sour gas.

Figure 1 Muskwa-Kechika Management Area


YUKON
BRITISH COLUMBIA
Watson Lake
Fort Liard
N W
BRITISH
ALBERTA
BRITISH
Dease River
104P
104P
094N
094O
094P
Muncho Lake
Toad River
Summit Lake
Fort Nelson
104I
094L
094K
094J
094I
Prophet River
Besa-Prophet Management Plan
Upper Sikanni Management Plan
104H
094E
094F
094G
094H
Pink Mountain
Tatlatui Lake
Thutade Lake
094C
094B
094A
Fort St. John
Dawson Creek
Pouce Coupe
Granisle
Middle River Village
Fort St. James
Burns Lake
Fraser Lake
N
Study Area
Fort Nelson
Fort St. John
Dawson Creek
Prince Rupert
BRITISH COLUMBIA
Prince George
Bella Coola
Golden
Kamloops
Pacific Ocean
Campbell River
Vancouver
Cranbrook
Victoria

tera
CALGARY, ALBERTA

Sources:

Muskwa Kechika Management Area Boundary:
BC Ministry of Sustainable Resource Management 2000
Hydrology: © 2000. Government of Canada with permission from Natural Resources Canada.

Legend

▬	Muskwa-Kechika Management Area Boundary
☐	Besa-Prophet Management Plan
☐	Upper Sikanni Management Plan
○	City / Town
—	Road
	Major Watercourse
	Waterbody
☐	1:250,000 map sheet grid

SCALE: 1:3,500,000

25 0 25 50 75 Kilometers

(All Locations Approximate)

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of this data are advised that errors in the data may be present

FIGURE 1

REGIONAL LOCATION

MUSKWA-KECHIKA MANAGEMENT AREA HELIPORTABLE DRILLING STUDY

2555

June 2002

2.0 PREVIOUS HELIPORTABLE EVALUATIONS IN NORTHEASTERN BC

A number of project-specific heliportable drilling evaluations have been carried out in BC. The level of analysis has varied considerably among these evaluations. These are described briefly below and include information on technical and safety considerations, cost and the basis for their rejection, where this information was available. The cost differences provided, are based on evaluations conducted prior to the project and may or may not reflect the actual differences. In most cases, costs for road reclamation were not provided though can be assumed to approximate or be slightly less than road construction costs.

2.1 Amoco Canada Petroleum Company Ltd. (Beattie Peaks, 1991)

Amoco Canada Petroleum Company Ltd. (Amoco) considered heliportable drilling for their exploratory sour gas well (a-64-A/93-0-15) on Beattie Peaks, south of the MK. Though environmental arguments weighed strongly, Amoco rejected heliportable drilling on the basis of the following:

- risk to workers in the event of an accident or blow-out; and
- high potential for inclement weather to hamper helicopter-based rescue and relief efforts (TERA 1991).

This well was drilled and unsuccessful.

2.2 Talisman Energy (PCP Falls, 1994)

Talisman Energy considered heliportable drilling for its PCP Falls well near Chetwynd, BC (TERA 1994). The well location was within an alpine cirque and required construction of an approximate 17 km road through rough mountainous topography including traverse of an alpine ridge. This high elevation location was prone to high frequency of low visibility conditions from fall through early spring. No cost evaluation was prepared and heliportable drilling was rejected due to the following concerns:

- concern over safety and sour gas;
- lack of available depth and torque rated heliportable rig;
- believed high probability of success; and
- concern over weather conditions at well site.

Construction of the particular road access to the location was fraught with a large number of stability and environmental problems which resulted in the road taking considerably longer to build and being extraordinarily costly (approximately $12 million) (Staniland pers. comm.). The well was drilled and unsuccessful.

2.3 Imperial Oil Limited (Belcourt Creek, 1995)

Imperial Oil Limited (IOL) conducted a relatively detailed evaluation of the feasibility of heliportable drilling a sour gas well near Belcourt Creek in northeast BC on an alpine ridge at 6,200 m elevation (Imperial Oil Limited 1995). IOL concluded a helicopter option introduced substantial incremental risks and costs that were not acceptable under IOL's Operations Integrity Risk Management Framework. Instead, a conventional 24.5 km access road was built to this location. Based on IOL's analysis, conventional construction and drilling costs for a dry hole at Belcourt were estimated at $9.3 million, which included approximately $3.5 million for road construction. The helicopter accessed and supported construction and drilling costs were estimated at $15 million, with the difference being $5.7 million. IOL included an emergency trail in their heliportable option (Imperial Oil Limited 1995). Imperial did not include a cost for full road reclamation. If it is assumed that reclamation costs are the same as construction costs, the full cost of the IOL's conventional program was about $12.7 million ($9.3 million + $3.5 million) and the difference between the two alternatives was approximately $2.3 million.

IOL's primary concerns were as follows:

- the inability to guarantee access to address well control and medical emergencies;
- the significantly greater expense associated with new access creation in the event of a blow-out; and
- significant environmental damage associated with new access creation in the event of a blow-out.

The well was drilled and was unsuccessful.

2.4 Murphy Oil Company Ltd. (Sikanni, 1996)

Murphy Oil Company Ltd. (Murphy) evaluated access methods, including a heliportable operation for well sites within their Petroleum Tenure, located north of the Sikanni Chief River and at the south end of the MK. The conventional access proposal for b-33-B/94-G-6 included provision for construction of a new 2 km road up a deeply incised valley (TERA 1996a).

Total cost for heliportable drilling was estimated at $8.4 million, while a conventional road accessed well was estimated at $7 million, including reclamation costs. Helicopter transportation costs were estimated at $2.7 million, which was approximately $1.4 million more expensive than conventional transportation costs.

Although Murphy recognized the environmental advantages of heliportable drilling, this option was ultimately rejected. The reasons for this decision were:

- the high costs of helicopter operations;
- the potential for increased costs in case of well bore or weather problems;
- anticipated delays due to weather and logistics such that drilling would not be completed on time; and
- anticipated requirement for a road for pipelining, development and production.

(Murphy Oil Company Ltd. 1996).

The well was drilled in 1997 and was unsuccessful. A second well from the same pad was successful.

2.5 Husky Oil Operations Ltd. (Sikanni, 1996)

Husky Oil Operations Ltd. (Husky) considered the feasibility of a helicopter based exploration program for their exploratory well (c-53-J/94-G-3), located south of the Sikanni Chief River. The access road followed existing linear disturbances for much of it's length and forest removal was required for approximately 2.8 km (TERA 1996b). The heliportable option was rejected for the following reasons:

- presence of a good, low impact winter access alternative along an existing linear disturbance;
- site characteristics believed to lend themselves to access control;
- concerns over the heliportable cost increment;
- safety; and
- uncertainty around the logistical and regulatory issues.

This well was drilled in 1997 and produced for approximately one year.

2.6 Murphy Oil Company Ltd. (Chicken Creek, 1999)

Murphy evaluated the feasibility of a heliportable drilling program at their exploration well (b-94-B/94-G-6) in the Chicken Creek valley. The primary reasons for going with a non-heliportable drill were as follows:

- the location had a good, low impact alternative winter access option available to it (snow road up dry creek bed and flat willow terraces);
- Chicken Creek afforded the opportunity to develop a very low impact winter access road up the stream channel;
- emergency medical evacuation; and

- additional perceived expense and uncertainty associated with heliportable drilling was believed to offer minimal environmental benefit relative to alternative. Based on this, it was determined that heliportable drilling in this site-specific case, would garner relatively little significant environmental benefit relative to the costs from an environmental, safety and economic perspective (TERA 1999).

A development well was also drilled in the same valley (c-76-B/94-G-6) the following year. Both the exploration and development well were unsuccessful.

2.7 Ricks Nova Scotia Co. (Ladyfern, 2000)

Ricks Nova Scotia Co. (Ricks) applied to the BC Oil and Gas Commission to use helicopters to transport a drilling rig and for drilling operations support at their a-98-H/94-H-1 well site located in the Ladyfern area. A helicopter would be used until such time as a winter road could be built. Ricks stated in their application that a helicopter supported drilling program would expand the operating window for remote or inaccessible areas from the winter period only to year-round operation and minimize environmental impacts. In the "Reasons for Decision" provided by the BC Oil and Gas Commission, a heliportable operation was not supported for the following reasons:

- the risk of an uncontrolled blow-out is similar to or greater than that for conventional drilling;
- risk of losing control is greater for a heliportable operation if loss circulation materials are not stored at the well site or have been depleted, or if transportation of these materials is hampered by helicopter availability or flying conditions;
- reliance on helicopters to transport equipment and materials in a heliportable operation results in a greater potential risk of losing control when compared to conventional road accessed operations;
- if complete loss of a well occurs, the risk of significant environmental impacts is greater for a helicopter supported operation. Delays related to helicopter availability and inclement weather may exacerbate the problem;
- if an uncontrolled flow incident occurs, reliance on helicopter transportation may delay the implementation of, or limit the effectiveness of clean-up and recovery measures;
- consequences of bringing in a relief rig;
- significant environmental damage may result if a loss of well control occurs and results in the release of fluids and if an emergency access road is required; and

- Ricks had also applied for two other wells in the same area accessed by winter roads, therefore the environmental benefits of heliportable would not be realized.

(BC Oil and Gas Commission 2000).

Ricks used heavy lift helicopters (Chinook 234 and Vertol 107) to construct portions of their approximate 32 km access road, primarily along areas of muskeg in the Ladyfern area. Several medium helicopters were also used for crew changes and equipment transport. In doing so, Ricks saved time (three weeks) and money using helicopter support for access construction, compared to conventional road access construction. The a-98-H/94-H-1 well was successful.

2.8 Marathon Canada Ltd. (Koller Creek, 2001)

Marathon Canada Ltd. (Marathon) evaluated the use of heliportable drilling at their well site (c-40-J/94-G-3), located within a subalpine basin on the east side of Mount Wooliever in the Upper Sikanni special management area. The basin was subject to a habitat enhancement burn conducted by the Ministry of Environment, Lands and Parks in the 1980s. A new 3.6 km access road was required and included a 2.2 km traverse through mixed black spruce, white spruce and aspen forest, and 1.4 km through the enhancement burn (TERA 2001). The heliportable transportation and service costs were estimated at $3.1 million (Fire Creek Resources Ltd. 2001). The actual road construction and reclamation costs were approximately $1.5 million (includes $200,000 for a temporary crossing of the Sikanni Chief River and $500,000 for reclamation of low impact winter road)(Patterson, pers. comm.). Based on these figures the net difference in transportation costs (and therefore approximate difference between conventional and heliportable options) was approximately $1.6 million ($3.1 million to $1.5 million).

In rejecting heliportable drilling for their exploration well, Marathon provided the following reasons:

- the incremental cost of heliportable drilling;
- the availability of a natural access control option at a major river crossing;
- the limited time available in the drilling schedule to plan and schedule a heliportable drill;
- concern over weather interference with heliportable access;
- uncertainty around the potential to get a successful water well at the site;
- concern over emergency response;
- ease of existing well site and access reclamation;
- lack of industry guidelines or standards for heliportable drilling;
- lack of training standards for air and ground support crews; and
- expressed concerns by OGC about implementing a heliportable program.

This well was drilled in the winter of 2002 and was suspended.

2.9 Ministry of Energy, Mines and Petroleum Resources 1995 Study

In addition to the above project specific evaluations, the BC Ministry of Energy Mines and Petroleum Resources commissioned a study in 1995 of "*Alternatives for Conducting Oil and Gas Exploration in Sensitive Areas of Northeastern British Columbia*" (Berlie 1995). This study also examined heliportable drilling and highlighted many of the concerns identified above and elsewhere in the present study. The 1995 study reported the following:

- the primary environmental concern associated with conventional exploration drilling relates to public access with motorized vehicles;
- the government is opposed to heliportable drilling in sour gas zones without road access due to concern over risk management associated with sour gas and with blow-out control unless it can be clearly demonstrated these issues can be managed;
- adequate back up heliportable drilling rigs and service equipment are not available in North America for support of an exploratory special sour well in northeast BC;
- conventional rigs can be modified for heliportable drilling but these will require design modifications, have operational limitations and safety issues that must be resolved; and
- recommendations that a procedure be developed for: the presentation and evaluation of alternative technologies in sensitive areas; studies to determine the design modifications for conventional drilling rigs; detailed studies of the service equipment required for heliportable drilling and it's availability; a detailed listing of North American heavy lift helicopter availability; further studies of safety and operational risk; and a five well demonstration project where these wells all had road access.

3.0 CONTEMPORARY PERSPECTIVES ON HELIPORTABLE DRILLING

Oil and gas companies, drilling operators and helicopter companies were canvassed as to their opinions, concerns and experience with regard to heliportable drilling. Questions focused on their past experience with heliportable drilling and their concerns with it. These responses are provided in Appendix A, and are briefly summarized below.

3.1 Oil and Gas Industry

Of the 13 oil and gas companies contacted for this study, a total of five provided responses. Common concerns regarding heliportable drilling included the following:

- economics: heliportable drilling is expected to be more expensive in most cases, and potentially negatively affect exploration drilling economics;
- safety: emergency evacuation in the event of a medical emergency and/or blow-out; and
- equipment availability: there is a limited availability of deep drilling capability rigs in North America.

3.2 Helicopter Companies

During the course of this study, contact was made with a number of helicopter companies in the interest of identifying the level of experience within the industry with heliportable drilling, the specifications of equipment used, specific concerns regarding site locations and operating conditions and costs.

Key contacts in regard to operating experience with heliportable drilling operations and heavy lift operations were Columbia Helicopters, Inc. (Columbia) of Portland, Oregon and Helifor Industries Limited (Helifor) of Vancouver, BC. Columbia has completed over 150 heliportable drilling moves worldwide, while Helifor has been actively engaged in heliportable logging operations in remote coastal BC locations for many years. Other helicopter companies that provided input were Canadian Helicopters and Vancouver Island Helicopters in Fort St. John, BC.

Key planning issues related to heliportable drilling that were identified included the following:

- safety;
- adequate space;
- coordination between subcontractors; and
- proper load sequencing.

From their experience, the primary reason heliportable drilling has been rejected has been related to the availability of economically more favorable surface access.

Helicopter companies were aware of the view that drilling requires 24-hour medical evacuation and noted that this was at variance with standard practice throughout much of BC. It was noted that much work goes on in remote areas, lacking 24-hour access in all weather conditions and is not in violation of WCB of BC requirements.

While there is always the risk of dropping loads during a heliportable operation, this was described as very uncommon, due to the high standards employed during such operations in the helicopter industry. It was mentioned that there were anecdotal reports indicating large loads are lost or spilled during conventional oilfield truck hauling. The helicopter industry believed the focus of comparison should be on whether heliportable drilling can provide for a comparable level of risk management as conventional road-based drilling rather than on a requirement for risk elimination.

Based on their experience, heliportable drilling has the following advantages:

- fast;
- environmentally sensitive;
- minimizes road construction and reclamation expenses;
- more economical depending on site conditions and remoteness; and
- heliportable drilling potentially allows drilling to occur outside of the winter season.

3.3 Drilling Companies

Key issues identified by Parker Drilling and Drillers Technology Corp. that need to be resolved prior to a heliportable drilling program were:

- costs;
- industry regulations;
- environmental restrictions; and
- industry recognized procedures and practices are required to ensure risks are minimized or removed.

In their view, other than costs, all aspects of heliportable drilling are feasible.

3.4 Provincial Government Staff

Formal interviews were conducted with three individuals from the BC OGC (Glenn, Doyle, Krezanoski pers. comm.) and two individuals from the BC Ministry of Water Land and Air Protection (Ackerman, Backmeyer pers. comm.) in addition to several informal inputs from other interested parties. The key issues related to heliportable drilling identified were:

- the need for practical applied experience with heliportable drilling;
- the need for financial incentives;
- frequent availability of alternate access tends to reduce the compelling case for heliportable drilling;
- concern over the ability to maintain adequate supplies and expediently provide spare parts during heliportable drilling; and
- potential need for a relief rig, the time required to provide this and environmental consequences of delay during a blow-out.

4.0 REGULATORY AND POLICY REVIEW

Existing legislation and regulations that are relevant to the question of helicopter-supported oil and gas operations were reviewed to identify any physical and regulatory constraints and gaps associated with helicopter-supported oil and gas operations in BC. The oil and gas industry in BC is regulated under the *Petroleum and Natural Gas Act* and regulations. The policy and guideline support for the industry is contained in the BC Oil and Gas Handbook (Ministry of Energy Mines and Petroleum Resources 1995). In addition to this, worker safety is regulated under the *Workers' Compensation Act*, Occupational Health and Safety Regulations (WCB of BC 2002). In 1998, the BC OGC was created under the *Oil and Gas Commission Act* to provide a one-window regulator for the oil and gas industry in BC.

BC has relied on strong industry initiative and cooperative planning rather than a detailed prescriptive regulatory environment. This regulatory environment has allowed rapid and ongoing change to new technologies throughout the 50-year history of commercial oil and gas activity in BC. The creation of the BC OGC has resulted in a more structured regulatory environment with the formalization of results-based practices in operational codes and guidelines.

A review of the relevant legislation and guidelines are provided in more detail below.

4.1 Petroleum and Natural Gas Act

The *Petroleum and Natural Gas Act* is enabling legislation providing bounds and definitions and empowering regulations to manage the oil and gas industry. The *Act* authorizes the expenditure of funds to "construct, reconstruct or repair trails, roads and bridges to facilitate exploration, development or production of petroleum or natural gas, or both" (BC OGC 1998a), but is otherwise silent on authorizing heliportable access.

4.1.1 Drilling and Production Regulation

The Drilling and Production Regulation to the *Petroleum and Natural Gas Act* (BC Regulation 362/98) is also silent on the typology and use of access methods. Its nine sections are for the large part non-prescriptive, relying on the submission and authorization of plans to ensure issues are addressed rather than specifying equipment or techniques (BC OGC 1998b).

4.2 Workers' Compensation Act

The *Workers' Compensation Act* covers the regulation and management of worker safety in BC. This *Act*, as amended by the *Workers' Compensation (Occupational Health and Safety) Amendment Act*, is one of the BC's largest and most complex pieces of legislation. The *Act* is administered through a number of regulation instruments. The Occupational Health and Safety

(OHS) Regulation (BC Regulation 296/97) provides comprehensive regulation of the working environment in BC (WCB of BC 2002).

4.2.1 The Occupational Health and Safety Regulation

This regulation is the operational instrument that implements the *Workers' Compensation Act*. Regulation of the use of helicopters for the transport of drilling operations is covered by the Occupational Health and Safety Regulation. Helicopter drilling operations do not have a specific set of regulations but the use of helicopters for transport of workers and equipment is covered. Heliportable drilling would require specific attention and compliance with Regulations in Part 4 (General Conditions), Part 23 (Oil and Gas), Part 29 (Aircraft Operations) and Part 33 (Occupational First Aid).

It is worthy of note that OHS regulations recognize: the provision, use and scheduling of work activities and resources in the workplace, including planning, organizing, staffing and coordinating, for the purpose of controlling risk (Part 1.1) (WCB 2002).

4.3 Oil and Gas Commission Act

The *Oil and Gas Commission Act* identifies the purpose of the OGC. This includes the following:

(a) regulate oil and gas activities and pipelines in BC in a manner that:
  (i) provides for the sound development of the oil and gas sector, by fostering a healthy environment, a sound economy and social well being,
  (ii) conserves oil and gas resources in BC,
  (iii) ensures safe and efficient practices, and
  (iv) assists owners of oil and gas resources to participate equitably in the production of shared pools of oil and gas,
(b) provide for effective and efficient processes for the review of applications related to oil and gas activities or pipelines, and to ensure that applications that are approved are in the public interest having regard to environmental, economic and social effects,
(c) encourage the participation of First Nations and aboriginal peoples in processes affecting them,
(d) participate in planning processes, and
(e) undertake programs of education and communication in order to advance safe and efficient practices and the other purposes of the commission.

(BC OGC 1999).

Provisions (a)(i),(iii) and (b) and (e) above provide a clear mandate and rationale for the BC OGC to consider the use of heliportable drilling and to develop necessary guidelines, review process and communication initiatives should it be implemented.

If there is a conflict or inconsistency between the *Oil and Gas Commission Act* and the *Muskwa-Kechika Management Area Act*, the *Muskwa-Kechika Management Area Act* prevails.

4.4 Muskwa-Kechika Management Area Act

The MK is administered under the *Muskwa-Kechika Management Area Act* (1998). The intent of the act is to maintain in perpetuity the wilderness quality and the diversity and abundance of wildlife and the ecosystems on which it depends while allowing resource development and use in parts of the MK designated for these purposes. The planning, development and management of access roads is central to achieving the long-term objective of returning lands to their natural state as development activities are completed. The planning and management of Crown land and natural resources in the MK must be conducted in accordance with the MK Management Plan, which enacts the objectives found in the Land and Resource Management Plans (LRMPs) (*Muskwa-Kechika Management Area Act* 1998).

4.5 BC Oil and Gas Commission Maximum Disturbance Review Criteria Code and Guideline

The Maximum Disturbance Review Criteria (MDRC) has the primary objective of encouraging companies, construction contractors and service firms to reduce environmental impact and consider land use and water management techniques in development plans and operational strategies. It describes preferred maximum disturbance allowances for the development of well sites, access routes, pipeline right-of-ways and other associated project requirements (*e.g.*, remote sumps, decking sites, camp sites and borrow pits) (BC OGC 2002).

The MDRC provides some criteria for the proponent in the OGC Application Review Process. It states that compliance with provincial and federal legislation is mandatory and includes recommendations to clients regarding planning strategies and application preparation, size and spacing of new disturbance and construction techniques. Each application is examined on an individual basis. Construction proposals that meet the objectives of the MDRC will require a less prescriptive review, expediting application review time. Rationale must be provided for any project or associated activity that exceeds MDRC guidelines (BC OGC 2002). It is notable that the MDRC does not mention access methods and is silent on aircraft operations, including helicopters.

4.6 Conclusion

Beyond general regulatory requirements for safe and environmentally responsible oil and gas exploration and development, there are no explicit regulatory constraints to heliportable drilling provided in the acts and regulations. The reason for heliportable drilling not being approved to date, has been based on continued uncertainty around its ability to be carried out in a manner that minimizes significant safety and environmental risks.

5.0 REFERENCES

5.1 Personal Communications

Ackerman, Andy. Ministry of Water, Land and Air Protection. Fort St. John, British Columbia

Backmeyer, Rod. Ministry of Water, Land and Air Protection. Fort St. John, British Columbia

Doyle, Derek. BC Oil and Gas Commission. Fort St. John, British Columbia

Glenn, Les. BC Oil and Gas Commission. Fort St. John, British Columbia

Hunley, Tony. Airborne Energy Solutions. Calgary, Alberta.

Krezanoski, Dave. BC Oil and Gas Commission. Fort St. John, British Columbia.

Patterson, Bernie. Marathon Canada Limited Calgary, Alberta.

Staniland, Rob. Talisman Energy. Calgary, Alberta

5.2 Literature Cited

Accumap. 2002. Oil and Gas data for Map Sheets 94 G (2,3,6,7,10,11).

Alberta Energy and Utilities Board. 2001. Alberta Drilling Activity, Monthly Statistics. December 2001.

BC Government. 1997. The Muskwa-Kechika Management Plan. *Muskwa-Kechika Management Area Act*. Queen's Printer, Victoria, British Columbia, Canada.

BC Government. 1998. *Muskwa-Kechika Management Area Act*. Queen's Printer, Victoria, British Columbia, Canada. www.legis.gov.bc.ca/1998-99/1st_read/gov37-1.htm.

BC Oil and Gas Commission. 1998a. *Petroleum and Natural Gas Act*. Chapter 361. Queen's Printer, Victoria, British Columbia, Canada. www.qp.gov.bc.ca/statreg/stat/P/96361_01.htm.

BC Oil and Gas Commission. 1998b. Drilling and Production Regulation to the *Petroleum and Natural Gas Act* (BC Regulation 362/98). Queen's Printer, Victoria, British Columbia, Canada. www.qp.gov.bc.ca/statreg/reg/P/PetNatGas/PetNatGas362_98/362_98.htm.

BC Oil and Gas Commission. 1999. *BC Oil and Gas Commission Act*. Chapter 39. Queen's Printer, Victoria, British Columbia, Canada. www.qp.gov.bc.ca/statreg/stat/o/98039_01.htm.

BC Oil and Gas Commission. 2000. Reasons For Decision. Application for a Well Authorization and Helicopter Supported Drilling Proposal a-98-H/94-H-1, WA#13027

BC Oil and Gas Commission. 2002. Maximum Disturbance Review Criteria. www.ogc.gov.bc.ca/fc_appinfo.asp. April 2002.

Berlie, E.M. 1995. Alternatives for Conducting Oil and Gas Exploration in Sensitive Areas of Northeastern British Columbia - A Preliminary Study. Prepared for the Engineering and Operations Branch, Ministry of Energy, Mines and Petroleum Resources (Service Contract #95-22). October 1995. 29 pp + appendices.

Fire Creek Resources Ltd. 2001. Logistics and Cost Study for a Heli-portable Drilling Alternative. Marathon Koller Creek d-40-J/94-G-3.

Imperial Oil Limited. 1995. Risk and Cost Analyses of Access Options for Drilling Imperial Belcourt a-53-K / 93-I-8. February 1995. 40 pp + appendices.

Murphy Oil Company Ltd. 1996. Evaluation of Access Methods for Exploration Drilling within BC P&NG Tenure 951060B Murphy Gulf Chicken Creek B/94-G-6. October 1996.

TERA Environmental Consultants (Alta.) Ltd. 1991. Amoco Carbon Creek Gas Exploration and Development Project - Environmental Impact Assessment and Mitigation Report. Prepared for Amoco Canada Petroleum Company Ltd.

TERA Environmental Consultants (Alta.) Ltd. 1994. Environmental evaluation and caribou protection plan for Talisman PCP Falls d-86-E well site application. Talisman Energy Inc.

TERA Environmental Consultants (Alta.) Ltd. 1996a. Environmental Assessment for the Murphy Oil Company Ltd. Gulf Canada Resources Limited Chicken Creek c-32-B Gas Exploration Project

TERA Environmental Consultants (Alta.) Ltd. 1996b. Environmental Assessment for the Husky Oil Operations Ltd. Sikanni c-53-J (d-54-J Bottom Hole) / 94-G-3 Gas Exploration Project. Prepared for Husky Oil Operations Ltd.

TERA Environmental Consultants (Alta.) Ltd. 1999. Habitat Impact Assessment for the Proposed Murphy Oil Company Ltd. b-94-B/94-G-6 Gas Exploration Well and Access Road. Prepared for Murphy Oil Company Ltd. November 1999.

TERA Environmental Consultants. 2001. Habitat Impact Assessment and Environmental Protection and Reclamation Plan for the Marathon Canada Limited Proposed c-40-J/94-G-3 Well Site and Access Road. Prepared for Marathon Canada Limited.

US Forest Service and Bureau of Land Management. 1992. Chevron USA Inc. Hunter Creek Exploratory Well Environmental Assessment and Finding of No Significant Impact. January 1992.

Workers' Compensation Board of BC. 2002. Occupational Health and Safety Regulations. http://regulation.healthandsafetycenter.com/s/Home.asp.

APPENDIX A

EXAMPLE OF QUESTIONNAIRE AND RESPONSES

List of Respondents

Oil and Gas Companies:
Ray Shepert, Murphy Oil Company Ltd., Calgary, Alberta
Bill Petersen, Canadian Natural Resources Limited, Calgary, Alberta
Mike Reed and Kip Pratt, Shell Canada, Calgary, Alberta
Rob McManus, Calpine Canada Resources Ltd., Calgary, Alberta
Murray Pow, Husky Energy Inc., Calgary, Alberta

Drilling Companies
Mirko Edgar, AH&L Ground Support and Logistics Services, Lima, Peru
Randy Crowson, Parker Drilling, Houston, Texas
Barry Luft and Orville Cole, Fire Creek Resources Ltd., Calgary, Alberta
Treena Pare, Drillers Technology Corp., Calgary, Alberta

Helicopter Companies
Gary McDermid, Helifor Industries Limited, Vancouver, British Columbia
Todd Peterson, Columbia Helicopters, Inc. Portland, Oregon
Murray Adamson, Canadian Helicopters, Fort St. John, British Columbia
Corey Taylor, Vancouver Island Helicopters, Fort St. John, British Columbia

MUSKWA-KECHIKA HELIPORTABLE DRILLING FEASIBILITY STUDY QUESTIONNAIRE

Drilling Contractors and Oil and Gas Companies

1. Has your company ever been involved in heliportable deep gas or oil drilling (excluding heli-seismic)?

2. What was the nature of your company's involvement?

3. How many heliportable wells has your company drilled or provided support for?
***Note:* Please fill out "Form 1" for each heliportable well drilled. Three forms have been provided at the end of this questionnaire.**

4. In your view, what are the key issues that require resolution prior to deciding on heliportable drilling?

5. If your company has not been involved in heliportable drilling, name any companies that you are aware of that have used heliportable drilling and where this was undertaken?

6. Has your company ever considered heliportable drilling? If yes, explain why? If no, how come?

7. In cases where heliportable drilling was considered, but not selected, what were the primary reasons it was not selected?

8. If heliportable drilling was a required condition of operations in an environmentally sensitive area with moderate potential for a large volume discovery, would this be a deterrent to bidding on a land sale in the area?

9. In your view, what are the key benefits of heliportable drilling?

10. In your view, what are the key deterrents to the use of heliportable drilling and how might these be resolved?

11. Please provide any other comments

FORM 1 - Well 1

Please complete for each heliportable well

Project	
Company	
Location of well	
Year well was drilled	
Why was heliportable rig used	
Type and supplier of rig	
Maximum hook load	
Altitude (above sea level)	
Depth of well	
Success of well	
Approximate total cost of drilling and completions/abandonment	
Approximate size of well pad	
Where was the campsite located	
How large was the campsite	

Identify any other necessary heli-support sites/ heli-staging areas and approximate size	
Approximate amount of potential new conventional road access avoided by use of heliportable rig at this site.	
Length of time required to construct well site	
Was any additional time required to prepare staging area (how much)	
Type, number and charge-out rate of helicopters used	
Maximum payload handled	
Season and total duration of drilling program	
Was flying restricted to daylight hours	
Approximate number of no fly days caused by weather	
Number of no fly days caused by other problems (*e.g.*, mechanical)	
Water supply	
Sump wastes (onsite or flown to remote)	
Product (sweet/sour gas/oil/water)	
Was there an emergency medical facility and staff on-site (if yes, please describe)	

Did you have an Emergency Relief Well Plan (was there provision for a relief rig? How would the relief well been drilled in the event of a blow-out? How would rig have been mobilized?)	
How was the need for emergency site evacuation planned/addressed	
Were there any accidents that were directly attributable to the use of a heliportable drilling rig	
Was alternate land access available. What was it.	
Were there any problems encountered attributable to heliportable operations	

Please add any other comments.

QUESTIONNAIRE RESPONSES

Key issues that require resolution prior to deciding on a heliportable drilling program

- Heliportable drilling is expected to be more expensive in most situations, which will negatively impact the project economics on an "exploration risk" basis.

- Limited number of deep drilling capability heliportable rigs available in North America, which would limit industry ability to execute drilling plans. It would not be economic to construct a fleet for use in MK only.

- Include emergency evacuation, risk of crash, logistics during blow-out, etc. In the event of a sour well blow-out, the rig crew must immediately put on breathing air packs and evacuate up-wind to the edge of the emergency planning zone (EPZ). Vehicles are normally parked on the well site facing towards the exit to minimize the time required to reverse and turn around. The planning zone may be up to 5 km radius. Air supply in the portable breathing air pack is approximately 30 minutes, so average rate of travel during an evacuation must be at least 10 km/hr (*i.e.*, for a 5 km planning zone, assuming travel is in a straight line, and physical exertion is low). Air packs cannot be safely changed in a sour environment. Flying a helicopter while wearing an air pack is unimaginable. The description of how a sour well blow-out is brought under control is beyond the scope of this answer, but suffice to say road access is mandatory. In conclusion, heliportable drilling should not be contemplated for areas with potential for sour gas.

- Road building is usually cheaper (depending on distance) and provides for wheeled vehicle access for the life of the well. For heliportable drilling to be viable economically, several factors must be considered such as how close can the staging area be located in relation to the lease site? Generally, helicopters will be required to access the well for its life. Would roads be a cheaper alternative in the long run? Are there legal and environmental issues that preclude the construction of roads?

- Select the helicopter that can carry the best weight/price per kilo delivered to the drill site from the staging area (the helicopter that can lift the most weight is not always the most efficient). The staging area should be as close to the drill site as possible but elevation, weather and prevailing wind should be a consideration. Enroute terrain should be considered as long climbs affect turn around times and ultimately price per kilo.

- The operator must resolve the cost of a heli job vs. a conventional job and the environmental aspect as well as possible miles of road/bridges etc. that are required.

- Environmental restrictions, industry regulations and heliportable drilling economics.

- Safety (equipment, personnel and well control) and economics. In a well control situation it may be difficult to get men and supplies to a location because of weather or reduced daylight flying hours in the winter. Moving heavy equipment by helicopter is inherently more risky for personnel on the ground and in the helicopter.

- Wider seasonal window, helicopter safety audit, onsite "hospital".

- Worker safety evacuation (removing injured workers) during inclement flying conditions and establishing engineering/contingency standards for well control problems (develop best practices).

- Heliportable drilling would be more acceptable where drilling is straight forward and drilling parameters are well known (no loss circulation, minimal chance of problematic hole conditions), medium depth for rig availability, sweet gas or oil, optimum weather conditions for operation (summer). Sour gas compounds risk. Well control and evacuation would be "greatly hampered" without land access for urgent evacuation should winds shift.

Has your company ever considered heliportable drilling?

- No, because heliportable drilling has not been a condition of the tenure; road access has usually followed existing disturbance (such as seismic trails) or been based on winter-only construction techniques; weather conditions (wind and cloud) have been too harsh to plan for consistent flying, and the deep foothills wells we have drilled have all had potential to encounter sour zones, and consequently the safety risk of heliportable drilling would have been unacceptably high.

In cases where heliportable drilling was considered, but not selected, what were the primary reasons it was not selected?

- The cost of heliportable drilling outweighed the economics of expected reserves and falling gas prices at the time.

- Precedence setting, cost, seasonal limitations, weather delays.

If heliportable drilling was a required condition of operations in an environmentally sensitive area with moderate potential for a large volume discovery, would this be a deterrent to bidding on a land sale in the area?

- Yes. Safety issues are still a substantial concern for the industry as well as ability to meet BC safety regulations for an operation of this nature. Hydrocarbon targets within the MK contain varying levels of H_2S, therefore, for the purposes of safety and liability most if not all prudent operators would require a surface emergency access/egress route prior to spudding a well. We suspect these issues would be a deterrent for any prudent and competent operator. The Province should expect this condition to affect the value of the mineral rights, and consequently expect to receive a lower price for the land. The only operators willing to bid might be too naïve or inexperienced to recognize the potential risks.

- The estimated costs to drill a well of this nature are prohibitive to smaller O&G companies who may not want to assume the risk or do not have the budget for exploratory drilling.

- Most likely this would result in a deterrent as the increased well costs would result in a poor economic potential.

- The well costs would escalate 5 to 7 times, so the economics would have to support this.

- The additional costs/risks would be factored into the bid (in the same manner that other costs/risks would be, such as building a road).

In your view, what are the key benefits of heliportable drilling?

- The key benefit is minimizing new access into pristine habitat, provided the well is unsuccessful, and provided access is not created later for other use. If the well is successful, access will be created for pipelines and operations, so the benefit will be lost. If access is created later for other use, such as timber harvest, the benefit will also be lost. In both cases, the cost, in terms of reduced value of mineral rights, will remain. The difference is that, in the first case, the risk is an unknowable probability, while the second case would be an example of poor planning.

- If you cannot reach the location via road and want to test a structure, this is a viable method for exploration with minimal environmental impact.

- Expanding the operating window currently limited to winter access only. Environmental impact and economics of construction to and from well site removed. Plus clean-up and reclamation of site and access on completion of drilling if no production is encountered. With experience, both of the above items allow for the possibility of developing smaller, less productive reserves throughout Western Canada.

- Avoid the high cost of road building in severe terrain, better choice of drill sites in severe terrain and less impact on a sensitive environment. There always seems to be one or two loads that are too heavy and cannot be broken down.

- Overcome location that is impossible to access with a relatively easy well to drill with a very low perceived risk of encountering H_2S or other potential drilling problems.

- Environment (no footprint) and the risk of spills increases dramatically.

- Cost savings (where costs of roaded access would exceed helicopter assisted drilling).

In your view, what are the key deterrents to the use of heliportable drilling and how might these be resolved?

- Economics: include heliportable drilling as a condition of the tenure in appropriate locations (*i.e.*, pristine, high exploratory risk, no future timber harvest, remote and difficult road access, good staging).

- Safety: only consider heliportable drilling for sweet gas prospects with no sour gas potential. Unfortunately, this most likely precludes any prospects in the MK.

- High cost.

- The cost of having to build a staging area and camp at the closest road, and prolonged bad weather on a drill move.

- Due to the lack of regulations and procedures, in the event of a blow-out or other emergency, a helicopter is not deemed adequate to provide support. Industry recognized procedures and practices must be created to ensure all associated risks are minimized or removed.

- Costs, safety issues.

- Need to have all conceivable equipment and services onsite to react to any incident as weather may not allow flight.

- Standards/Best Practices regarding well control contingency measures (creates due diligence, problems/liabilities). Create regulatory standards or industry recognized practices. Specially designed equipment/experience - resolve through royalty incentive programs (or other financial incentives).

MUSKWA-KECHIKA MANAGEMENT AREA HELIPORTABLE DRILLING FEASIBILITY STUDY

ENVIRONMENTAL REPORT

Prepared for:

BC Ministry of Sustainable
Resource Management,
Muskwa-Kechika
Advisory Board
and the
BC Oil and Gas Commission

Prepared by:

Randal Glaholt and Lois Pittaway

TERA Environmental Consultants
Suite 1100, 815 - 8th Avenue S.W.
Calgary, Alberta T2P 3P2

Brian Churchill

Chillborne Environmental Services
SS2 Site 22 Comp 23
Fort St. John, BC V1J 4M7

Harris Wheeler
AAEA Ltd.
Charlie Lake, BC V0C 1H0

June 2002
2555

EXECUTIVE SUMMARY

The Environmental Report provides background biophysical and resource management information of relevance to the feasibility of heliportable drilling in the Muskwa-Kechika Management Area (MK). The environmental impacts of conventional roads and helicopters are discussed along with their implications for subsequent development and production.

The MK is an area of unique wilderness in northeastern BC that is endowed with a globally significant abundance and diversity of wildlife. The management intent for the MK is to maintain in perpetuity the wilderness quality and the diversity and abundance of wildlife and the ecosystems on which it depends, while allowing resource development and use in parts of the MK designated for those purposes including recreation, hunting, timber harvesting, mineral exploration and mining, oil and gas exploration and development. Motorized vehicle travel is limited to designated routes within the MK that were determined on the basis of environmental sensitivity, public recommendation and past use.

Terrain conditions affect the level of difficulty and impact for both conventional and heliportable drilling operations. Narrow ridgelines and steeply sloping terrain are particularly difficult places to operate and to minimize impacts. Conventional road construction in these areas, tends to result in much larger impacts than other locations due to soils handling and slope stabilization requirements. To some extent, these impacts can be reduced by end-hauling excavated material and then restoring this material following site abandonment. Surface stabilization and vegetation re-establishment in such sites is particularly challenging and requires long-term commitment and attention. Locations in deeply incised valleys and small cirques often have associated climatic conditions that would present greater constraints for helicopter operation due to phenomenon such as turbulence and down drafts. Higher altitude sites pose a further constraint on heliportable operations as a result of the reduced lifting capacity of helicopters with increasing altitude, though this is not an overriding constraint on heliportable operations.

Drilling programs within the eastern third of the MK will tend to encounter sweet Mississippian gas and as such, incur lower relative risk and risk management requirements than Devonian plays to the west. To the extent that a company's risk management protocol requires road access for sour gas exploratory wells, application of heliportable drilling would be restricted to easterly Mississippian formations. Easterly Mississippian plays will tend to be shallower than those in the westerly Devonian and as such potentially allow access to a greater number of heliportable rigs. Regardless of sour gas presence, it is likely that generally larger (greater depth capability) heliportable rigs will be required for drilling targets in the western portion of the MK, though this will vary considerably with each location.

It is likely that drilling targets will tend to be identified on top of, or immediately adjacent to more mountainous topography, rather than in broad valley bottoms. These drilling targets will typically require more physical disturbance for conventional road accessed sites, likely require more ambitious directional drilling for conventionally accessed wells, as well as potentially pose more demanding flying conditions for a heliportable operation. Heliportable locations would likely result in less regulatory pressure for directional drilling to offset environmental impacts.

Climatic conditions occurring in the MK of relevance to heliportable drilling include cold temperatures, high winds, fog and low cloud cover, and icing. The frequency of occurrence and location of these conditions is highly variable. The occurrence of "no fly" conditions for the purpose of heliportable drilling is expected to be uncommon and typically be restricted to portions of a given day when such conditions do occur rather than preclude flying for the entire day.

Alpine tundra vegetation is highly sensitive to disturbance and is very slow to re-establish once disturbed. Unless alpine terrain is very gentle, low impact road construction (*e.g.*, using snow fill or other padding) is not possible. In this context, relatively greater impacts will occur using conventional road access compared with heliportable. Where there is a requirement to more aggressively reclaim and monitor alpine reclamation, a company could encounter potentially significant manpower and financial commitment. New road construction through forests within the MK would inevitably result in creation of a scar in the vegetation mosaic with attendant impact on the wilderness landscape aesthetic associated with the area. The presence of valley bottom areas dominated by willow, dwarf/scrub birch and/or meadows provides some opportunity for low impact road construction as an alternative to a heliportable operation. These vegetation communities provide the opportunity for construction of temporary winter access by walking over the vegetation and building snow/ice roads (with or without mowing) with potentially only minor impact to the landscape aesthetic and functional integrity of the affected vegetation communities.

The presence of high value and relatively high sensitivity fishery resources within the MK increases the need for fisheries specific research, planning, design, compensation and permitting where it involves conventional road construction. Heliportable access eliminates potential impacts caused by erosion, riparian habitat loss, and human fishing pressure to fish and aquatic ecosystems associated with more conventional road access as well as the costs and time associated with assessment and planning around these. Potential for spills during fuel hauling can arise with both conventional road accessed drilling programs as well as for heliportable drilling programs.

Wildlife can be significantly affected by both roads and helicopter activity though these impacts tend to be site-specific. In general, much greater and more prolonged impacts are typically associated with roads. Displacement effects related to roads and helicopters appears to be related to their proximity to key habitats, the level of activity and the manner in which species are exposed to that activity. Where alternate low impact road access is not available, heliportable drilling operations provide a much greater opportunity to avoid long-term impacts to wildlife habitat and wildlife, particularly for lower success rate exploration drilling. There remains some potential that heliportable operations could result in significant short-term stress and displacement of wildlife. The potential for longer-term range abandonment could occur where frequent helicopter site visits are required to locations within critical wildlife habitat or which may require low level flying enroute to a given location. The species with greatest potential to be impacted in this regard are likely Stone's sheep and mountain goat due to their strong reaction to helicopters and low flying aircraft as well as grizzly bear when this species may seasonally seek more open terrain.

Use and creation of conventional road access in this land use setting can, if sensitively planned, can create a desired and improved resource access alternative for some interests and individuals. For others, road development is believed to lead to a significant degradation of the environment and associated opportunities. Heliportable drilling has potential to alleviate some of these latter concerns, but the associated noise and activity can impair recreational experiences. To some extent, these helicopter impacts can be avoided through planning flight patterns and seasonal and daily timing restrictions, keeping in mind however, the desirability of maximizing daylight flying hours.

Guide outfitting success depends largely on the ability of guide outfitters to provide a high quality wilderness experience and a reasonably good chance for the client to obtain a trophy animal. Road construction for oil and gas exploration and development results in relatively long-term alteration of the landscape aesthetic and solitude, and has the potential to result in generally increased human use for motorized and equestrian access, unless this is effectively controlled. This increased access has the potential to increase industrial and recreational noise levels, as well as increase wildlife displacement and mortality. While guide outfitters may benefit by some limited access development, the overall effect of conventional road construction degrades the wildland experience and reduces the guide outfitter's ability to compete in the market place. Secondary support services such as airlines, hotels and other local businesses may also be affected. Confining oil and gas activity to the winter period in general, reduces overall impacts to guide outfitting though still results in some long-term adverse impacts, particularly where roads result in the removal of significant amounts of valuable wildlife habitat, creation of long-term unregulated access and degradation of the visual landscape.

Heliportable drilling avoids most of the long-term physical impacts of road development such as landscape modification and increased conventional access. These impacts are traded off with increased wide spread noise impacts and increased potential for displacement of sensitive high valued wildlife species in the MK such as Stone's sheep. Such impacts may be short-term where a well is unsuccessful, however, in the production scenario, helicopter noise impacts on the wildlife and the wilderness experience would be extended through a longer period (*e.g.*, many years). Adjustments to flying routes, scheduling of flights and specifying the type of helicopter may offset some of these impacts. Such adjustments may or may not add additional flying time and costs to heliportable operations. Adjustments to seasonal flying opportunities would have to be reconciled with interests in maximizing the daylight hour flying opportunities.

Development of unrestricted conventional road access provides potential opportunity for physically, improved access for equestrian users and clearly improves accessibility by motorized vehicle users. In the absence of effective management policies, this can in turn put motorized vehicle users in conflict with horse or foot-based recreationist including commercial backcountry operators not using motorized access. A helicopter based exploration program avoids the physical impacts of conventional road access and to some extent can be seen to replace the physical impacts with more intense acoustic impacts. Studies in other jurisdictions, to some extent, have confirmed that aircraft use is incompatible with the public's perception of the proper management and use of protected areas. Similar concerns were also raised for other forms of motorized recreation.

Conventional oil and gas access road development within areas also targeted for timber harvest affords some opportunity to subsidize road building costs for forest operators or mining interests and conversely road development by the forest industry or mining interests provides some opportunity to subsidize or defray road building costs associated with oil and gas activity. In some cases, oil and gas access roads have advanced timber harvest schedules where the two activities overlap and would be avoided in cases where heliportable drilling occurs.

A range of mitigation measures are available to reduce the potential impacts of both a heliportable drilling operation and more conventional land-based access. The magnitude of difference in environmental impact between the two basic alternatives is site-specific and may range from negligible to very significant. While in most cases relatively less physical impact will be associated with heliportable operations there may be site-specific cases where these exceed that of conventional low impact winter road construction. An example of this circumstance would be a case where a snow or ice fill road with minimal clearing requirement could be constructed to a narrow valley bottom location adjacent to occupied sheep or goat habitat.

A decision to allow road access during the production phase would negate many of the long-term benefits of heliportable drilling for successful wells. Where roads are constructed for long-term production potential indirect impacts on wildlife populations caused by displacement from human activity (as opposed to predator avoidance) could be potentially reduced by reducing the level of human activity on these roads. This could be achieved by allowing winter only industrial use as well as gating combined with enforcement, monitoring and education programs to control public use.

It is recommended that consideration be given to mapping and identifying areas which may be more or less suitable for heliportable drilling within the MK and that a more detailed review of the potential advantages and disadvantages of heliportable operations be undertaken.

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY i
1.0 INTRODUCTION 1
  1.1 Management within the Muskwa-Kechika Management Area 1
    1.1.1 Protected Areas, Parks and Ecological Reserves 3
    1.1.2 Access Management 3
2.0 ENVIRONMENTAL SETTING AND ITS SIGNIFICANCE 6
  2.1 Topography 6
  2.2 Hydrocarbon Geology and the Occurrence of Sour Gas 7
  2.3 Climatic Conditions 11
    2.3.1 Temperature 11
    2.3.2 Fog/Low Cloud Cover 14
    2.3.3 Precipitation and Icing 15
    2.3.4 Wind 20
    2.3.5 Heliportable Well Site Location and its Relationship to Climatic Concerns 23
  2.4 Day Length 24
  2.5 Vegetation 25
  2.6 Fish and Aquatic Ecosystems 27
  2.7 Critical Wildlife Habitat 27
  2.8 Land Use 31
    2.8.1 Guide Outfitting and Trapping 31
    2.8.2 Backcountry Recreation 33
    2.8.3 Forestry 34
    2.8.4 Mining 34
3.0 IMPACTS OF ROADS 35
  3.1 Impacts on Fish and Aquatic Ecosystems 35
  3.2 Impacts on Wildlife 36
    3.2.1 Moose 36
    3.2.2 Elk 36
    3.2.3 Caribou 37
    3.2.4 Mountain Sheep and Goats 38
    3.2.5 Grizzly Bear 38
    3.2.6 Birds 39
    3.2.7 Road Management Policy in the MK and Wildlife 39
4.0 IMPACTS OF HELICOPTERS 40
  4.1 Impacts on Wildlife 40
  4.2 Helicopter Flight Guidelines 44
  4.3 Impacts on Land Use 45
5.0 COMPARATIVE EVALUATION OF IMPACTS THROUGH THE LIFE CYCLE OF OIL AND GAS EXPLORATION AND DEVELOPMENT 46
  5.1 Seismic Program 46
    5.1.1 Conventional Seismic 46
    5.1.2 Heliportable Seismic 46
  5.2 Exploration Drilling 47
    5.2.1 Conventional Exploration Drilling 47
    5.2.2 Heliportable Exploration Drilling 48
  5.3 Field Development, Production and Operations 49
    5.3.1 Conventional Field Development, Production and Operations 49
    5.3.2 Heliportable Field Development, Production and Operations 50
  5.4 Abandonment and Reclamation 50
  5.5 Summary of the Environmental Impacts Through the Life Cycle 50

6.0 MITIGATION MEASURES 53
7.0 CONCLUSION 56
8.0 RECOMMENDATIONS 57
9.0 REFERENCES 58
9.1 Personal Communications 58
9.2 Literature Cited 58

LIST OF FIGURES

Figure 1 Environmental Factors Influencing Heliportable Drilling 1
Figure 2 Muskwa-Kechika Management Area 2
Figure 3 Land and Resource Management Zones 4
Figure 4 Parks and Protected Areas and Designated Access Routes 5
Figure 5 Terrain Slope Classification and Elevation 8
Figure 6 Distribution of Hydrocarbon Formations 9
Figure 7 Mean Monthly Temperatures (°C) for Muncho Lake 1970-2000 12
Figure 8 Mean Daily Temperature in Sikanni Area, 1995 (adapted from Sikanni Chief Weather Station) 12
Figure 9 Mean Monthly Precipitation for Muncho Lake 1970 to 2000 16
Figure 10 Total Monthly Precipitation in Sikanni Chief Area, 1995 (adapted from Sikanni Chief Weather Station) 16
Figure 11 Mean Monthly Wind Speed in Sikanni Chief Area, 1995 (adapted from Sikanni Chief Weather Station) 20
Figure 12 Wind Energy Resource Map 22
Figure 13 Vegetation Communities 26
Figure 14 Habitat Suitability of Stone's Sheep 29
Figure 15 Habitat Suitability of Mountain Goat 30
Figure 16 Guide Outfitting and Trapping Boundaries 32

LIST OF TABLES

Table 1 Average Monthly Temperatures (°C) for Selected Periods at Muncho Lake 13
Table 2 Averages and Extremes Data on Frost Events in the Muskwa-Kechika Management Area 13
Table 3 Average Monthly Total Rainfall, Total Snowfall and Total Precipitation Values for Muncho Lake for Selected Periods 17
Table 4 Day Length at Muncho Lake 24
Table 5 Summary of Research on the Impacts of Helicopter and Aircraft on Large Mammals 41
Table 6 Flight Guidelines in the Besa Prophet Management Area 44
Table 7 Summary of Environmental Impacts During Life Cycle 51
Table 8 Mitigation for Road-Based Exploration Programs 53
Table 9 Mitigation for Helicopter-Based Exploration Programs 55

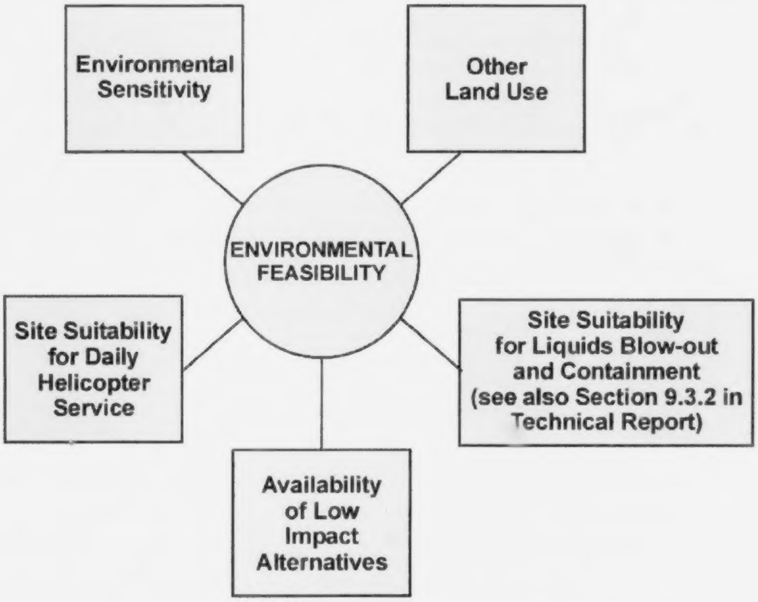
LIST OF PLATES

Plate 1 Example of side cast fill. 7
Plate 2 Example of "socked-in" conditions with heavy fog and low cloud cover. 17
Plate 3 View of Chicken Creek valley and low impact ice road to winter exploration well site. (Photo courtesy of Kaizen Environmental Services Inc.) 19
Plate 4 View along Chicken Creek in summer following construction of low impact ice road and well site. (Photo courtesy of W. Sawchuk). 19
Plate 5 Woodland caribou along access road 37
Plate 6 View of mountain goats on steep south-facing slope. 38

1.0 INTRODUCTION

This Environmental Report provides background biophysical and resource management information on the Muskwa-Kechika Management Area (herein referred to as the MK), of relevance to the feasibility of heliportable drilling. The environmental impacts of conventional roads and helicopters are discussed along with their implications for subsequent development and production. Five general factors are seen to influence the environmental feasibility of heliportable drilling (Figure 1). These factors are discussed in the following report.

Figure 1 Environmental Factors Influencing Heliportable Drilling


Environmental Sensitivity
Other Land Use
ENVIRONMENTAL FEASIBILITY
Site Suitability for Daily Helicopter Service
Site Suitability for Liquids Blow-out and Containment (see also Section 9.3.2 in Technical Report)
Availability of Low Impact Alternatives

1.1 Management within the Muskwa-Kechika Management Area

The MK is an area of unique wilderness located in northeastern BC (Figure 2). The area is 6.4 million hectares in size and remains one of North America's last true wilderness locations south of the 60th parallel. Activities in the MK are guided by the *Muskwa-Kechika Management Area Act* that identifies the MK as an area of unique wilderness in northeastern BC that is endowed with a globally significant abundance and diversity of wildlife. The management intent for the MK is to maintain in perpetuity the wilderness quality and the diversity and abundance of wildlife and the ecosystems on which it depends, while allowing resource development and use in parts of the MK designated for those purposes including recreation, hunting, timber harvesting, mineral exploration and mining, oil and gas exploration and development. In addition, the long-term maintenance of wilderness characteristics, wildlife and its habitat is critical to the social and cultural well-being of First Nations and other people in the area (BC Ministry of Sustainable Resource Management 2002a). The *Muskwa-Kechika Management Area Act* mandates pre-tenure plans, Land and Resource Management Plans and specific plans such as the Wildlife Management Plan and Recreation Management Plan.

Figure 2 Muskwa-Kechika Management Area

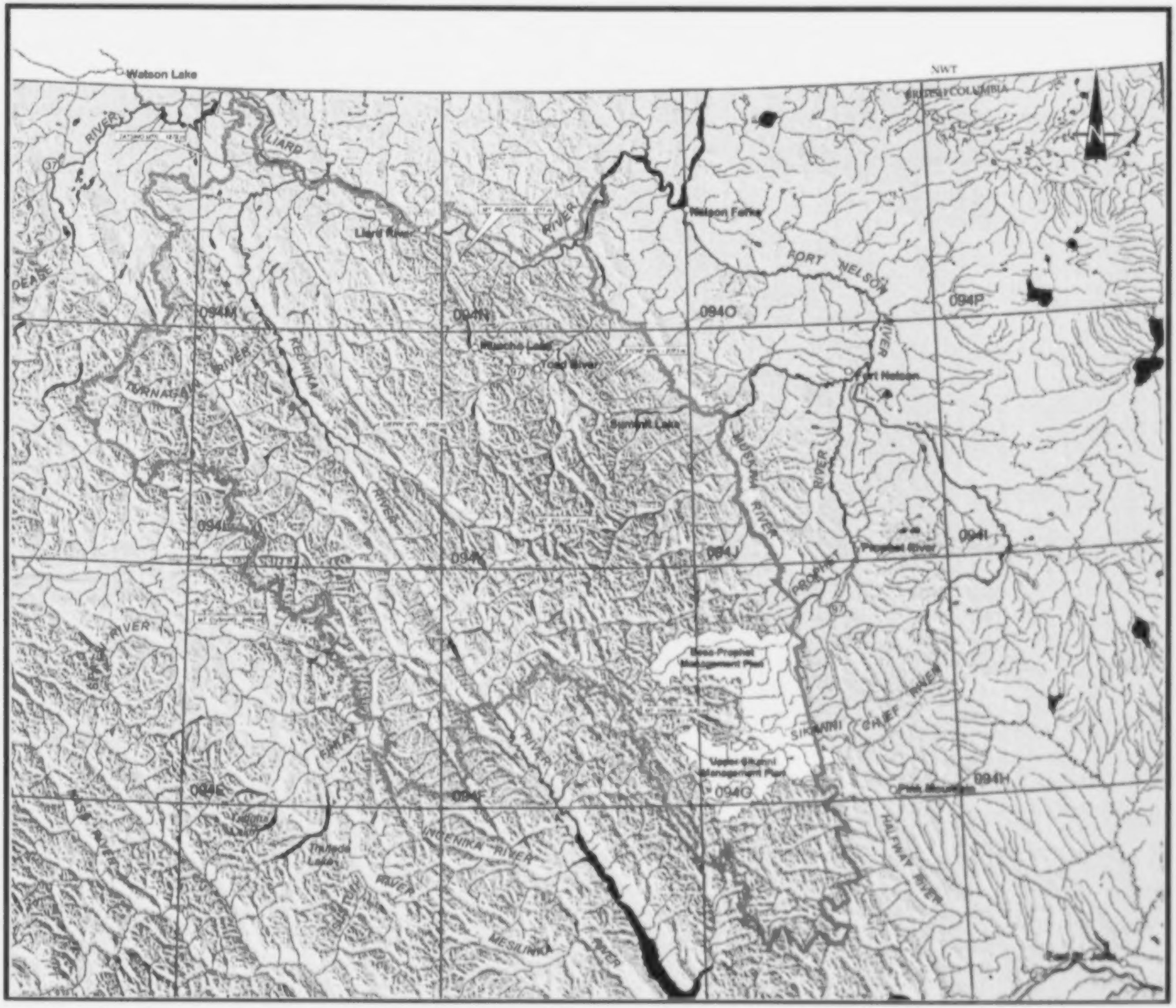

Watson Lake
NWT
BRITISH COLUMBIA
LIARD
RIVER
DEASE
RIVER
Liard River
Nelson Forks
FORT NELSON
RIVER
Fort Nelson
094M
094N
094O
094P
Muncho Lake
Toad River
Summit Lake
TURNAGAIN
RIVER
KECHIKA
RIVER
094L
094K
094J
094I
MUSKWA
RIVER
PROPHET
RIVER
Prophet River
SPATSIZI
RIVER
Besa-Prophet
Management Plan
Upper Sikanni
Management Plan
SIKANNI
CHIEF
RIVER
094E
094F
094G
094H
Pink Mountain
Thutade
Lake
FINLAY
RIVER
INGENIKA
RIVER
MESILINKA
RIVER
HALFWAY RIVER
97

FIGURE 2

REGIONAL LOCATION

MUSKWA-KECHIKA MANAGEMENT AREA
HELIPORTABLE DRILLING STUDY

LEGEND

▬	Muskwa-Kechika Management Area Boundary
☐	Upper Sikanni Management Plan Zone
☐	Besa-Prophet Pretarium Management Plan Zone (Draft)
○	City
—	Major Road
—	Major Watercourse
■	Waterbody
☐	1:250,000 map sheet grid
△	Mountain Peak

Sources

Muskwa Kechika Management Area Boundary:
BC Ministry of Sustainable Resource Management 2001
Hydrology: © 2000. Government of Canada with
permission from Natural Resources Canada.
Designated Access, Besa Prophet / Upper Sikanni
Management Area Boundaries: Ministry of Sustainable Resource Management 2002
Hillshade: BC Ministry of Environment, Lands and Parks 1999

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of this data are advised that errors in the data may be present.

SCALE: 1:1,750,000

0 | 1 | 2 | 3 | 4 Kilometers

All Locations Approximate

June 2002

2555

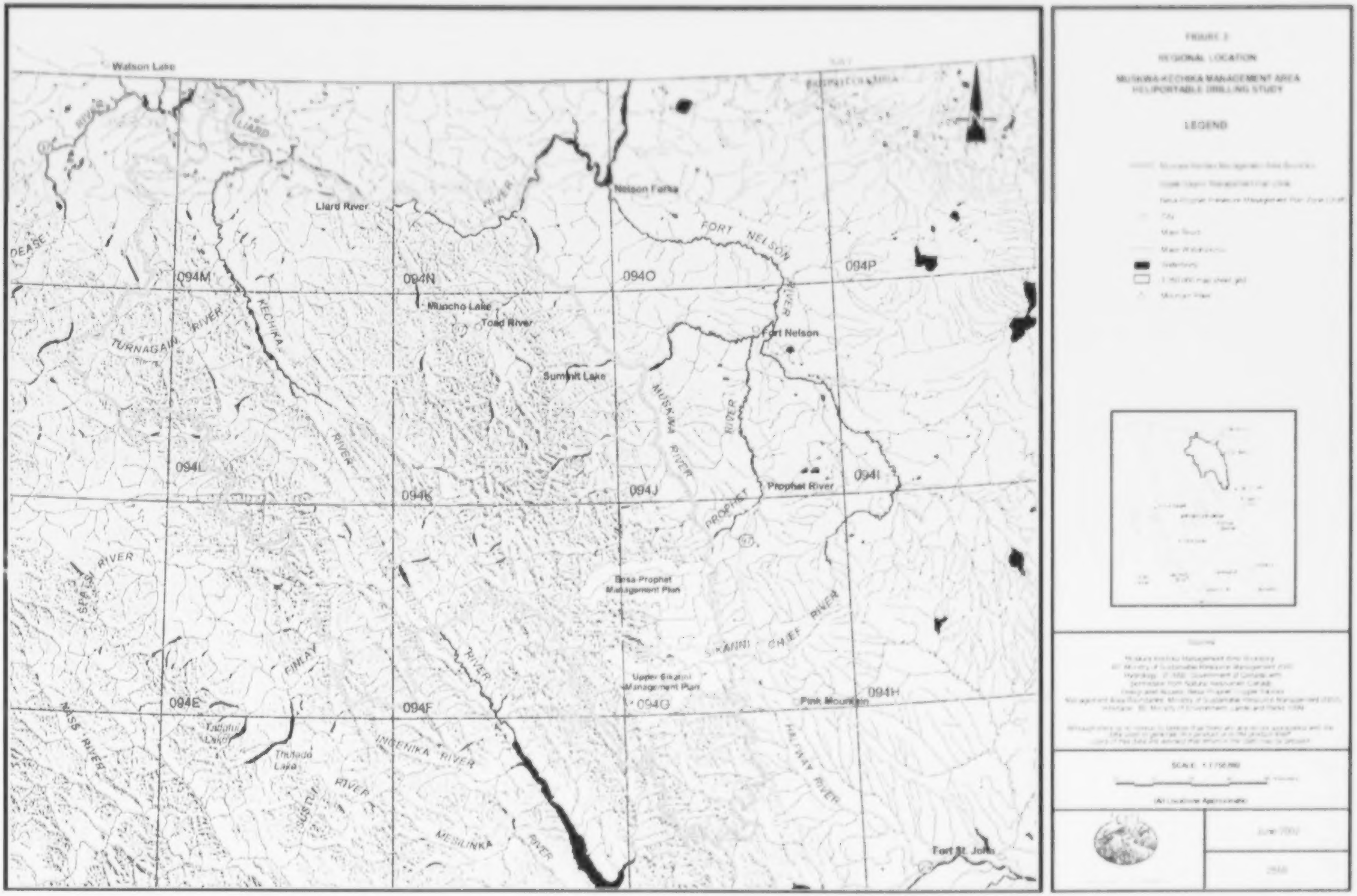

Watson Lake
LIARD
RIVER
DEASE
Liard River
Nelson Forks
FORT NELSON RIVER
094M
094N
094O
094P
Muncho Lake
Toad River
Summit Lake
Fort Nelson
TURNAGAIN RIVER
KECHIKA RIVER
MUSKWA RIVER
RIVER
094L
094K
094J
094I
Prophet River
PROPHET
SPATSIZI RIVER
FINLAY RIVER
Besa-Prophet Management Plan
Upper Sikanni Management Plan
SIKANNI CHIEF RIVER
094E
094F
094G
094H
Pink Mountain
NASS RIVER
Tatlatui Lake
Thutade Lake
INGENIKA RIVER
SUSTUT RIVER
HALFWAY RIVER
MESILINKA RIVER
Fort St. John

FIGURE 3

REGIONAL LOCATION

MUSKWA-KECHIKA MANAGEMENT AREA
HELIPORTABLE DRILLING STUDY

LEGEND

Waterbody
Mountain Peak

Sources

SCALE 1:1 750 000

(All Locations Approximate)

June 2002

Two pre-tenure plans have been established in the MK, the Upper Sikanni Management Plan (BC Ministry of Environment, Lands and Parks and BC Ministry of Energy Mines and Petroleum Resources 1995) and the Besa-Prophet Management Plan (BC Ministry of Sustainable Resource Management 2002b). Development within their boundaries must be consistent with objectives set out in each plan. Outside these areas, LRMPs overlapping the MK consist of the Fort St. John LRMP, Fort Nelson LRMP and the Mackenzie LRMP (Figure 3). The LRMPs provide a planning framework for resource development and incorporate the protection of environmental and recreational values through the implementation of objectives and strategies (Fort St. John LRMP 1997, Fort Nelson LRMP 1997, Mackenzie LRMP 2000).

1.1.1 Protected Areas, Parks and Ecological Reserves

Within the MK, there are several Protected Areas, Provincial Parks and Ecological Reserves (Figure 4). Oil and gas development is not permitted in the Protected Areas, however there is some likelihood that in the event a heliportable drilling program was to occur in the area, fly-overs of Protected Areas may be requested. Similarly, potential also exists for an industry request to use any existing road or access trail through these areas to reach nearby drilling locations and/or a potential helicopter staging area more proximate to a drilling location.

1.1.2 Access Management

Motorized vehicle travel is limited to designated routes within the MK that were determined on the basis of environmental sensitivity, public recommendation and past use. These routes include the Graham River Trail, Liard River Corridor, West Toad Corridor, Redfern Lake Trail, Cypress Creek Trail, Drogheda Lake Trail, Yedhe Creek Trail, Wokkpash Corridor, Chowadre River Trail, Racing River Trail, Nonda Creek Corridor, Sikanni River Trail and Halfway River Trail (Figure 4). Each of these trails falls under one of the following restrictions under the *BC Wildlife Act* and the Muskwa-Kechika Management Area Regulation:

- motor vehicles restricted to 400 m on either side of the route;
- motor vehicles restricted to a maximum of within 10 m of route;
- vehicles under 500 kg only restricted to 400 m on either side of route; and
- vehicles under 500 kg only restricted to a maximum of within 10 m of route.

(BC Ministry of Sustainable Resource Management 2002a).

In addition to these motorized vehicle restrictions, several management units within the MK, as identified in the Hunting and Trapping Regulations have vehicle closures. All motor vehicles are prohibited above 1,400 m in the following Management Units: 7-19, 7-31, 7-35, 7-36, 7-43, 7-53, 7-53, 7-57 and the SE portion of 7-21 except the Onion Lake Trail (7-21). No motor vehicles are allowed above 1,524 m elevation in the Bullmoose Chamberlain Mt. area, except the BP Canada/Ocelot Petroleum West Bullmoose Road (BC Ministry of Water, Land and Air Protection 2001).

Figure 3 Land and Resource Management Zones

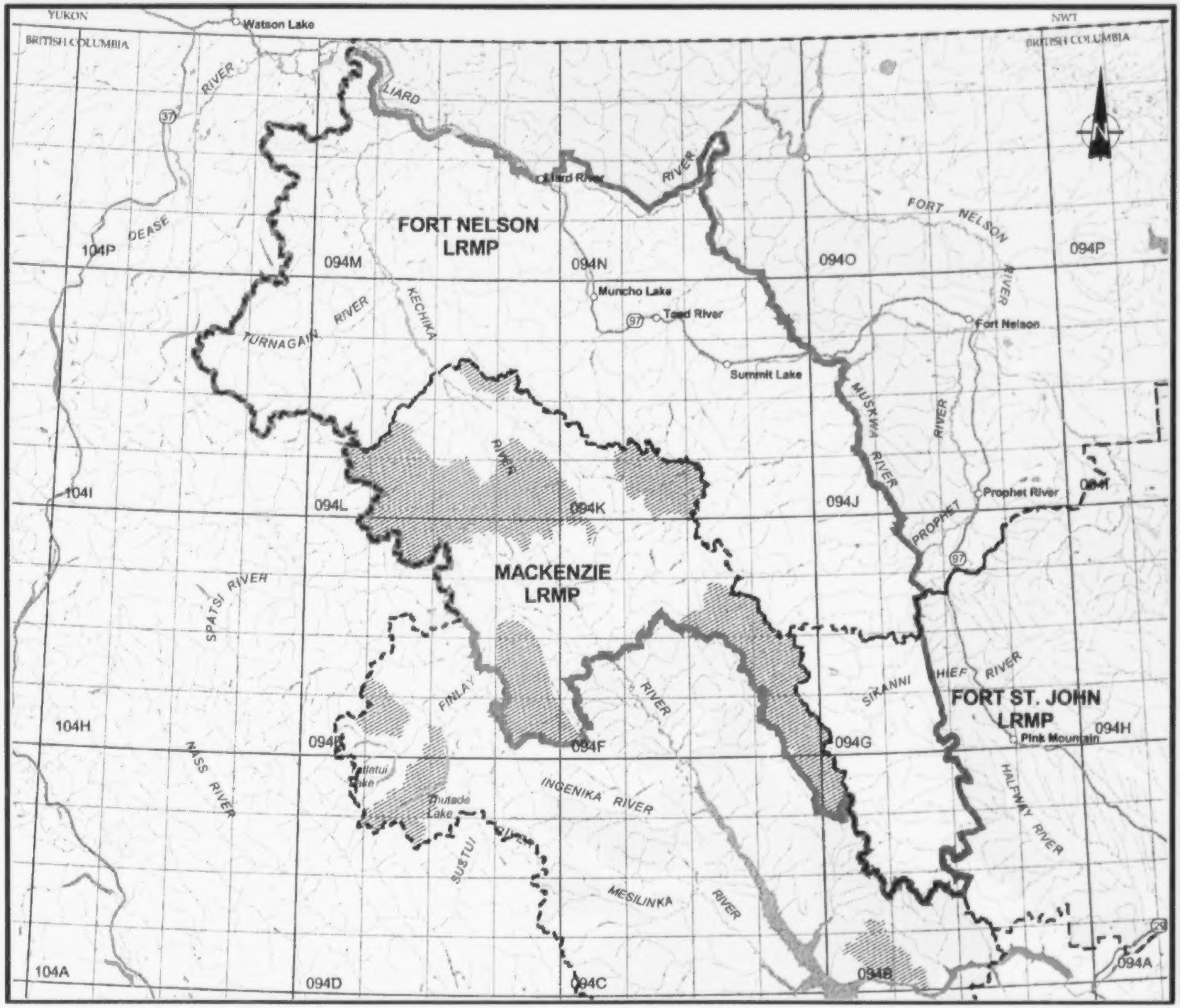

YUKON
BRITISH COLUMBIA
NWT
BRITISH COLUMBIA
Watson Lake
RIVER
37
DEASE
LIARD
Liard River
RIVER
FORT NELSON
RIVER
FORT NELSON LRMP
104P
094M
094N
094O
094P
Muncho Lake
97
Toad River
Fort Nelson
Summit Lake
TURNAGAIN
RIVER
KECHIKA
MUSKWA RIVER
RIVER
RIVER
Prophet River
PROPHET
97
104I
094L
094K
094J
094I
MACKENZIE LRMP
SPATSI RIVER
FINLAY
RIVER
SIKANNI
CHIEF RIVER
FORT ST. JOHN LRMP
Pink Mountain
104H
094E
094F
094G
094H
Tatlatui Lake
Thutade Lake
NASS RIVER
INGENIKA RIVER
SUSTUT
RIVER
HALFWAY RIVER
MESILINKA
RIVER
29
104A
094D
094C
094B
094A

FIGURE 3

LAND AND RESOURCE MANAGEMENT ZONES

MUSKWA-KECHIKA MANAGEMENT AREA
HELIPORTABLE DRILLING STUDY

LEGEND

Muskwa-Kechika Management Area Boundary
○ City
Major Road
Major Watercourse
Waterbody
☐ 1:250,000 map sheet grid
LRMP Boundary

Resource Management Zones

☐ Protected Area
▨ Special - Wildland
☐ Special Management
☐ General Management
☐ Agriculture/Settlement
☐ Enhanced Resource Development

Sources:

Muskwa Kechika Management Area Boundary:
BC Ministry of Sustainable Resource Management 2000
Hydrology: © 2000. Government of Canada with
permission from Natural Resources Canada
Land and Resource Management Zones: BC Land Use Coordination
Office 1997, 1998, 2000

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of this data are advised that errors in the data may be present

SCALE: 1:1,750,000

(All Locations Approximate)

CALGARY ALBERTA

June 2002

2555

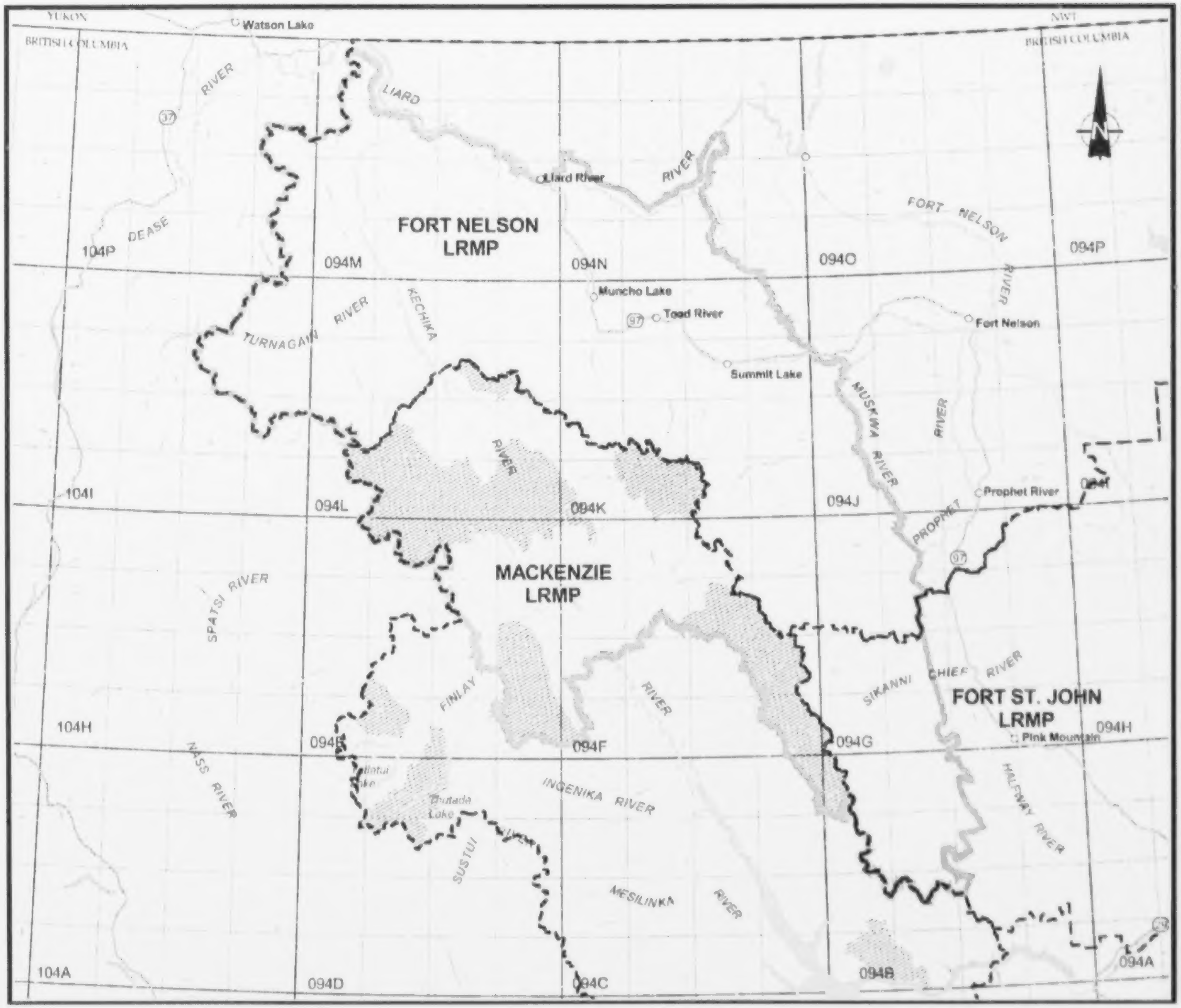

YUKON
BRITISH COLUMBIA
Watson Lake
NWT
BRITISH COLUMBIA
RIVER
DEASE
37
LIARD
Liard River
RIVER
FORT NELSON
RIVER
FORT NELSON LRMP
104P
094M
094N
094O
094P
Muncho Lake
97
Toad River
Fort Nelson
TURNAGAIN
RIVER
KECHIKA
Summit Lake
MUSKWA
RIVER
RIVER
RIVER
Prophet River
104I
094L
094K
094J
094I
PROPHET
97
MACKENZIE LRMP
SPATSI RIVER
FINLAY
RIVER
SIKANNI
CHIEF
RIVER
FORT ST. JOHN LRMP
104H
094E
094F
094G
094H
Pink Mountain
NASS RIVER
Thutade Lake
INGENIKA
RIVER
HALFWAY
RIVER
SUSTUT
RIVER
MESILINKA
RIVER
104A
094D
094C
094B
094A
N

FIGURE 3

LAND AND RESOURCE MANAGEMENT ZONES

MUSKWA-KECHIKA MANAGEMENT AREA
HELIPORTABLE DRILLING STUDY

LEGEND

Muskwa-Kechika Management Area Boundary
○ City
Major Road
Major Watercourse
Waterbody
▭ 1:250,000 map sheet grid
— — LRMP Boundary

Resource Management Zones
Protected Area
▨ Special - Wildland
Special Management
General Management
Agriculture/Settlement
Enhanced Resource Development

Sources:

Muskwa-Kechika Management Area Boundary:
BC Ministry of Sustainable Resource Management 2002
Hydrology: © 2002 Government of Canada with
permission from Natural Resources Canada
Land and Resource Management Zones: BC Land Use Coordination
Office 1997, 1999, 2000

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of this data are advised that errors in the data may be present.

SCALE: 1:1,750,000

(All Locations Approximate)

June 2002

2555

Figure 4 Parks and Protected Areas and Designated Access Routes

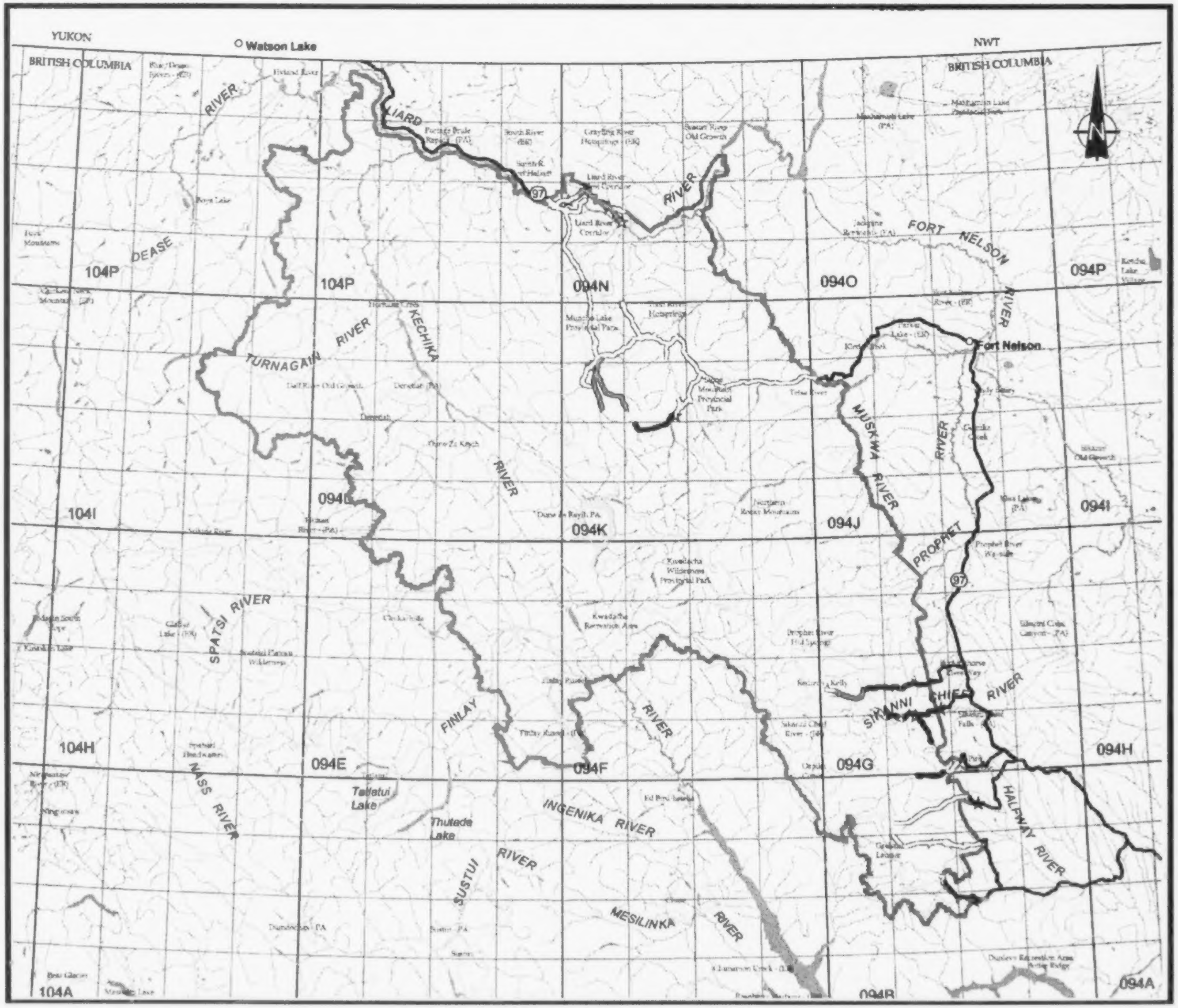

YUKON
BRITISH COLUMBIA
Watson Lake
NWT
BRITISH COLUMBIA
DEASE RIVER
LIARD RIVER
FORT NELSON RIVER
Fort Nelson
TURNAGAIN RIVER
KECHIKA RIVER
MUSKWA RIVER
PROPHET RIVER
SIKANNI CHIEF RIVER
HALFWAY RIVER
SPATSI RIVER
FINLAY RIVER
NASS RIVER
INGENIKA RIVER
SUSTUI RIVER
MESILINKA RIVER
Tatlatui Lake
Thutade Lake
97
104P
104P
094N
094O
094P
104I
094L
094K
094J
094I
104H
094E
094F
094G
094H
104A
094B
094A

FIGURE 4

PARKS AND PROTECTED AREAS AND DESIGNATED ACCESS ROUTES

MUSKWA-KECHIKA MANAGEMENT AREA HELIPORTABLE DRILLING STUDY

LEGEND

- ▬ Muskwa-Kechika Management Area Boundary
- ○ City
- — Major Watercourse
- ▬ Waterbody
- ▭ 1:250,000 map sheet grid
- Parks and Protected Areas
- Environmental and Land Use Act Corridors (ELUA)

MK Designated Access:

- ☆ Airstrip
- ═ Closed
- ═ Travel restricted to within 10 m of route
- ▬ Travel restricted to within 10 m of route (vehicles under 500 kg only)
- ═ Travel restricted to within 400 m of route
- ▬ Travel restricted to within 400 m of route (vehicles under 500 kg only)
- — Undesignated (i.e., Alaska Highway))

Sources:

Muskwa Kechika Management Area Boundary:
BC Ministry of Sustainable Resource Management 2000
Hydrology: © 2000. Government of Canada with
permission from Natural Resources Canada
Protected Areas: BC Ministry Environment, Lands and Parks 2001
Designated Access: Ministry of Sustainable Resource Management 2003b

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of this data are advised that errors in the data may be present.

SCALE: 1:1,750,000

20 0 20 40 60 Kilometres

(All Locations Approximate)

CALGARY ALBERTA

May 2002

2566

2.0 ENVIRONMENTAL SETTING AND ITS SIGNIFICANCE

The geographical position, diversity of landforms, aspects, waterbodies and forest cover types create a richness of habitats giving the MK a high diversity and abundance of wildlife. The area currently provides habitat for large mammals such as Stone's sheep, mountain goat, moose, woodland caribou, elk, bison, mule deer, white-tailed deer, grizzly bear, black bear, wolf, lynx, cougar and wolverine as well as numerous other species of small mammals, migratory and resident birds and invertebrates. The presence of an abundance of large mammal species with very high value for both consumptive (*e.g.*, recreational and commercial guide outfitting and trapping) and nonconsumptive use, in combination with what are considered some of the most scenic mountain wilderness landscapes in North America, has driven the development of a conservative management regime for the area.

Characteristics of the study area's biophysical environment of relevance to evaluation of heliportable feasibility/practicality are summarized in the subsections that follow.

2.1 Topography

The topography in the MK is highly variable and ranges from gentle to steep and mountainous. Slopes range from 0 to15% in the drainage bottoms and across ridge tops to greater than 35% on bedrock controlled slopes (Figure 5). Elevations range from approximately 1,200 m above sea level (asl) along the valley bottoms to approximately 2,600 m asl at the heights of land in the MK. The varied landscape includes rugged mountainous topography with exposed bedrock, broad east-west valleys such as those associated with the Graham, Halfway, Sikanni and Buckinghorse rivers and broad north-south valleys such as the Muskwa and Kechika rivers, various more deeply incised narrow valleys, broad and very narrow alpine ridge tops, and a variety of alpine basins or cirques.

Significance

Terrain conditions affect the level of difficulty and impact for both conventional and heliportable drilling operations. Narrow ridgelines and deeply incised valleys are particularly difficult places to operate. Conventional road construction in these areas tends to result in much larger impacts due to soils handling requirements, particularly due to side cast fill (Plate 1). To some extent, these impacts can be reduced by end-hauling excavated material and then restoring this material following site abandonment. Surface stabilization and vegetation re-establishment in such sites is particularly challenging and requires long-term commitment and attention. These same locations often have associated climatic conditions that may present a greater constraint to helicopter operation due to phenomenon such as turbulence and down drafts (see also Section 2.3.4). Higher altitude sites pose a further constraint on heliportable operations as a result of the reduced lifting capacity of helicopters with increasing altitude (10 to 12% for larger machines relative to sea level). Consideration must also be given to the potential for eventual production from any given location.

Plate 1 Example of side cast fill.

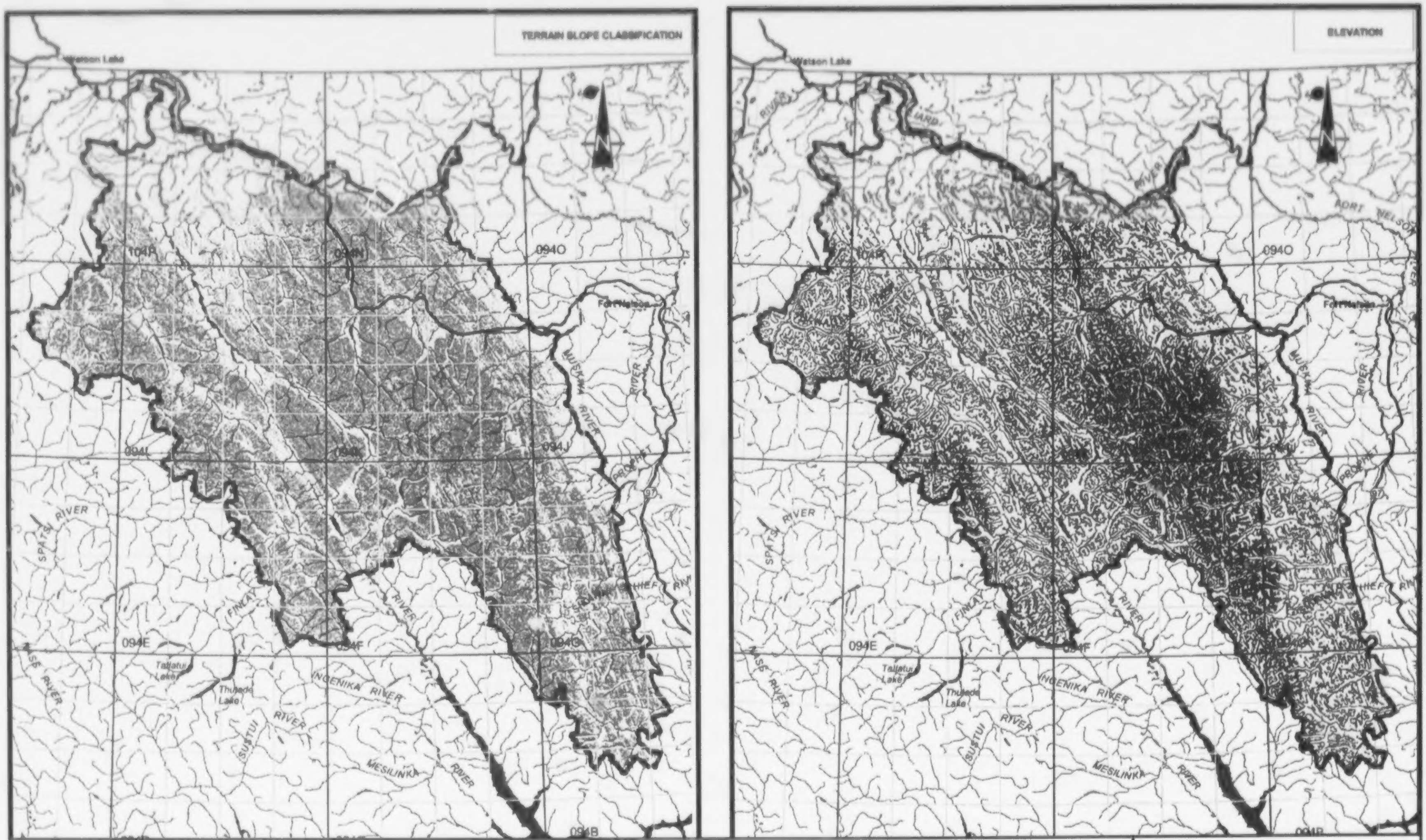
Conducting a heliportable drill on a suitable alpine site inevitably would, in the event of success, lead to eventual pipelining and production from the same site. An alternate road accessed well site up an adjacent confined valley (unsuitable for heliportable drilling) might in this same setting result in less impact, depending on the manner in which access is or otherwise needs to be controlled.

A final topographical concern relates to the suitability of a given location for the containment of an uncontrolled release of a large volume of liquids (frequently salt water) during a blow-out (see Technical report Section 9.3.2). Heliportable well sites set on steep sidehills will, in the rare case of such blow-outs, be less amenable to liquids containment and general blow-out control.

2.2 Hydrocarbon Geology and the Occurrence of Sour Gas

The hydrocarbon-bearing Western Canadian Sedimentary Basin includes most of the eastern MK. Hydrocarbons are potentially present within portions of the MK overlaying the basin at variable depths, depending on the formation. Mississippian gas bearing formations (*e.g.*, Debolt) lie along the eastern edge of the MK and typically produce sweet gas (Figure 6) (Ziebell pers. comm.). These lower pressure, frequently higher permeability formations range from about 1,000 m below the surface near the Prophet River down to approximately 3,500 m closer to the Williston Reservoir. These Mississippian formations are associated with a large aquifer such that wells in this formation tend to be sweet though may be sour to varying degrees (*e.g.*, 5% to 25%) and often produce water at some point in their production cycle. Immediately east of the MK boundary, the primary drilling targets are the Triassic formations (*e.g.*, Halfway and Baldonnel). These lower pressure, lower permeability formations typically yield sour gas, oil and water. Devonian formations (*e.g.*, Pine Point) lie generally west of the Mississippian at depths ranging from 2,500 m to 5,000 m and are typically porous sour gas producing formations. The Pine Point formation is a Devonian barrier reef structure that is believed to meander within the western portion of the MK. The characteristics of gas associated with the Pine Point formation in this area remain unknown though can be expected to exhibit higher pressures, lower permeability and have potential for high sour content. Devonian formations in other areas are frequently sour and this might also be expected of the Pine Point formation in this area. However, should it be associated with an active aquifer, then it may instead produce sweet gas. This latter phenomenon would be determined after the first exploratory wells are drilled in this formation within the MK.

Figure 5 Terrain Slope Classification and Elevation


TERRAIN SLOPE CLASSIFICATION
ELEVATION
Watson Lake
LIARD
RIVER
FORT NELSON
RIVER
Fort Nelson
MUSKWA RIVER
PROPHET
RIVER
CHIEF
SPATSI RIVER
FINLAY
RIVER
INGENIKA RIVER
Tatlatui Lake
Thutade Lake
SUSTUT
RIVER
MESILINKA
RIVER
KASE RIVER
97
104P
094N
094O
094L
094K
094J
094E
094F
094G
094B

SCALE 1:2,000,000

(All Locations Approximate)

May 2002

2855

Sources:

Muskwa Kechika Management Area Boundary: BC Ministry of Sustainable Resource Management 2000

Hydrology: © 2000. Government of Canada with permission from Natural Resources Canada

DEM: BC Ministry of Sustainable Resource Management 2002

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of this data are advised that errors in the data may be present.

LEGEND

- Muskwa-Kechika Management Area Boundary
- ○ City
- Major Road
- Major Watercourse
- ▬ Waterbody
- ☐ 1:250,000 map sheet grid

TERRAIN SLOPE CLASSIFICATION:

Slope Percent

- ☐ 0 to 10
- ☐ 10.1 to 16.0
- ☐ 16.1 to 36.0
- ▨ > 36.0

ELEVATION

- Elevation Contour (500 m)

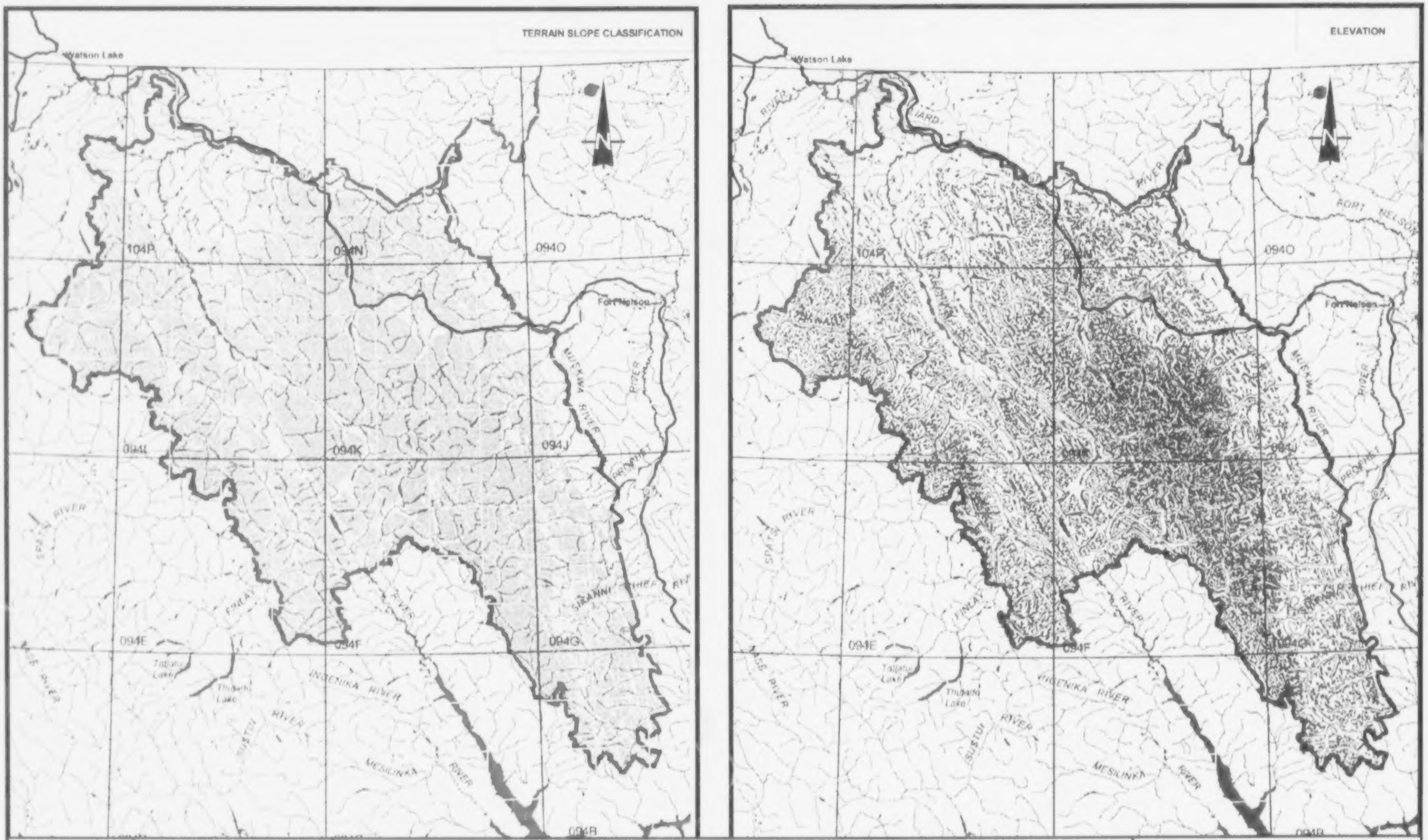
Elevation (m)

- ☐ 0 - 999
- ☐ 1000 - 1399
- ☐ 1400 - 1999
- ▨ 2000 - 3000

FIGURE 5

TERRAIN SLOPE CLASSIFICATION AND ELEVATION

MUSKWA-KECHIKA MANAGEMENT AREA HELIPORTABLE DRILLING STUDY


TERRAIN SLOPE CLASSIFICATION
ELEVATION
Watson Lake
Fort Nelson
104P
094N
094O
094L
094K
094J
094E
094F
094G
094B
LIARD
RIVER
FORT NELSON
MUSKWA RIVER
PROPHET
SIKANNI CHIEF RIVER
KECHIKA
SPATSIZI RIVER
FINLAY
INGENIKA RIVER
SUSTUT RIVER
MESILINKA
RIVER
NASS RIVER
Tatlatui Lake
Thutade Lake
N

SCALE 1:2,000,000

(All Locations Approximate)

May 2002

2555

Sources

Muskwa-Kechika Management Area Boundary
BC Ministry of Sustainable Resource Management 2000
Hydrology: © 2000. Government of Canada with
permission from Natural Resources Canada
DEM: BC Ministry of Sustainable Resource Management 2002

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of this data are advised that errors in the data may be present.

LEGEND

- Muskwa-Kechika Management Area Boundary
- City
- Major Road
- Major Watercourse
- Waterbody
- 1:250,000 map sheet grid

TERRAIN SLOPE CLASSIFICATION

Slope Percent
- 0 to 10
- 10.1 to 18.0
- 18.1 to 30.0
- > 30.0

ELEVATION

Elevation Contour (500 m)

Elevation (m)
- 0 - 999
- 1000 - 1399
- 1400 - 1999
- 2000 - 3000

FIGURE 5

TERRAIN SLOPE CLASSIFICATION AND ELEVATION

MUSKWA-KECHIKA MANAGEMENT AREA
HELIPORTABLE DRILLING STUDY

Figure 6 Distribution of Hydrocarbon Formations

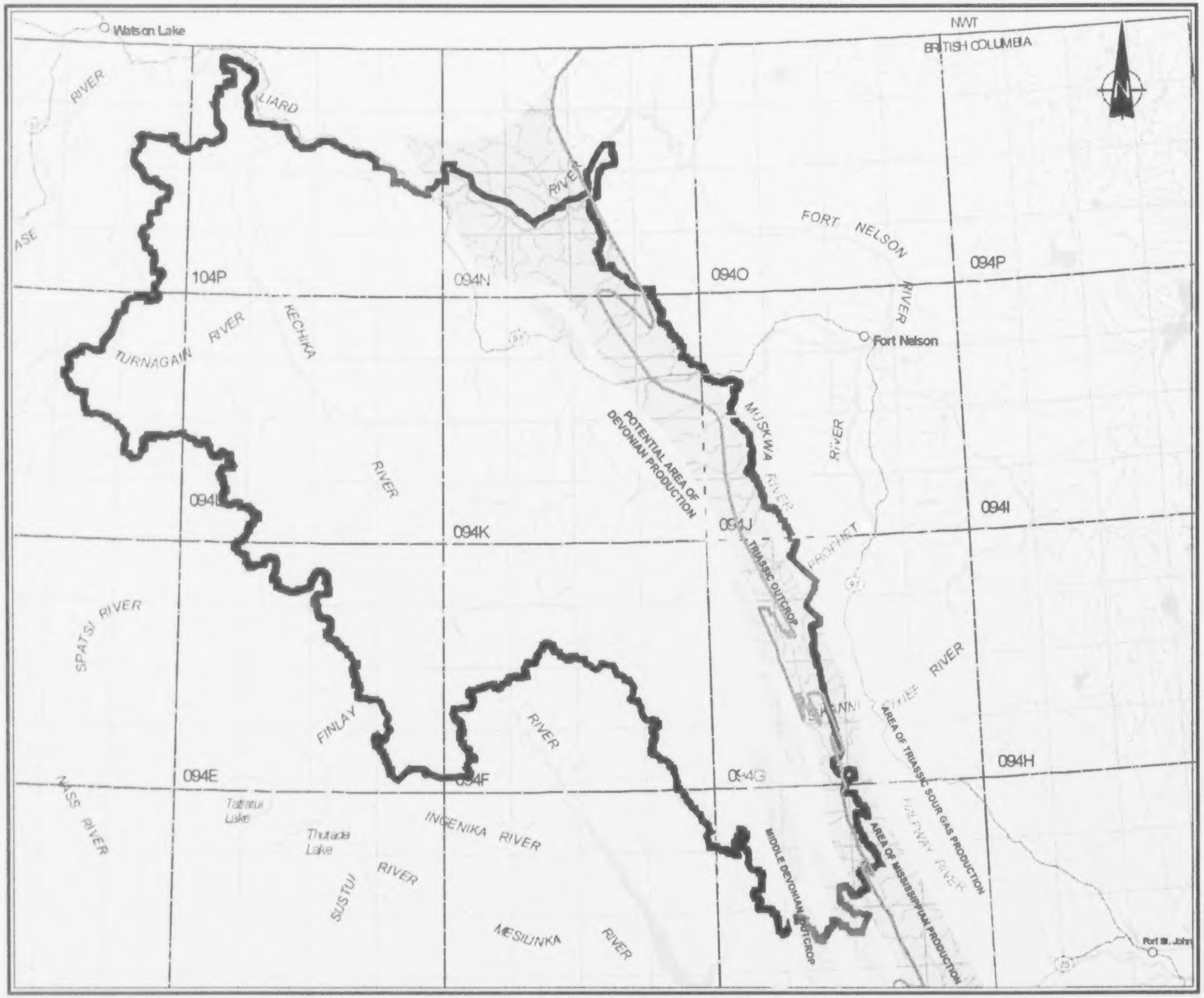

Watson Lake
NWT
BRITISH COLUMBIA
LIARD
RIVER
ASE
RIVER
FORT NELSON RIVER
Fort Nelson
104P
094N
094O
094P
TURNAGAIN RIVER
KECHIKA
RIVER
MUSKWA RIVER
RIVER
POTENTIAL AREA OF DEVONIAN PRODUCTION
094L
094K
094J
094I
TRIASSIC OUTCROP
PROPHET
SPATSI RIVER
FINLAY
RIVER
RIVER
AREA OF TRIASSIC SOUR GAS PRODUCTION
AREA OF MISSISSIPPIAN PRODUCTION
HALFWAY RIVER
094E
094F
094G
094H
Tatlatui Lake
Thutade Lake
INGENIKA RIVER
SUSTUT RIVER
NASS RIVER
MESILINKA RIVER
MIDDLE DEVONIAN OUTCROP
Fort St. John
97
29

FIGURE 6

DISTRIBUTION OF HYDROCARBON FORMATIONS

MUSKWA-KECHIKA MANAGEMENT AREA HELIPORTABLE DRILLING STUDY

Source: Ziebell pers. comm. 2002

Legend

Muskwa-Kechika Management Area Boundary
Watercourse
○ City or Town
Road

Hydrocarbon Formations:

Main Anticlinorium of Exploration Interest
Potential Area of Devonian Production
Area of Mississippian Production
Area of Triassic Sour Gas Production
Triassic Outcrop
Middle Devonian Outcrop
SW 1/4 94J: May also have potential for "regional" Devonian (i.e., not thrusted)

Scale: 1:1,750,000

Km 0 20 40 60

(All Locations Approximate)

tera ENVIRONMENTAL CONSULTANTS
CALGARY, ALBERTA

2555

June 2002

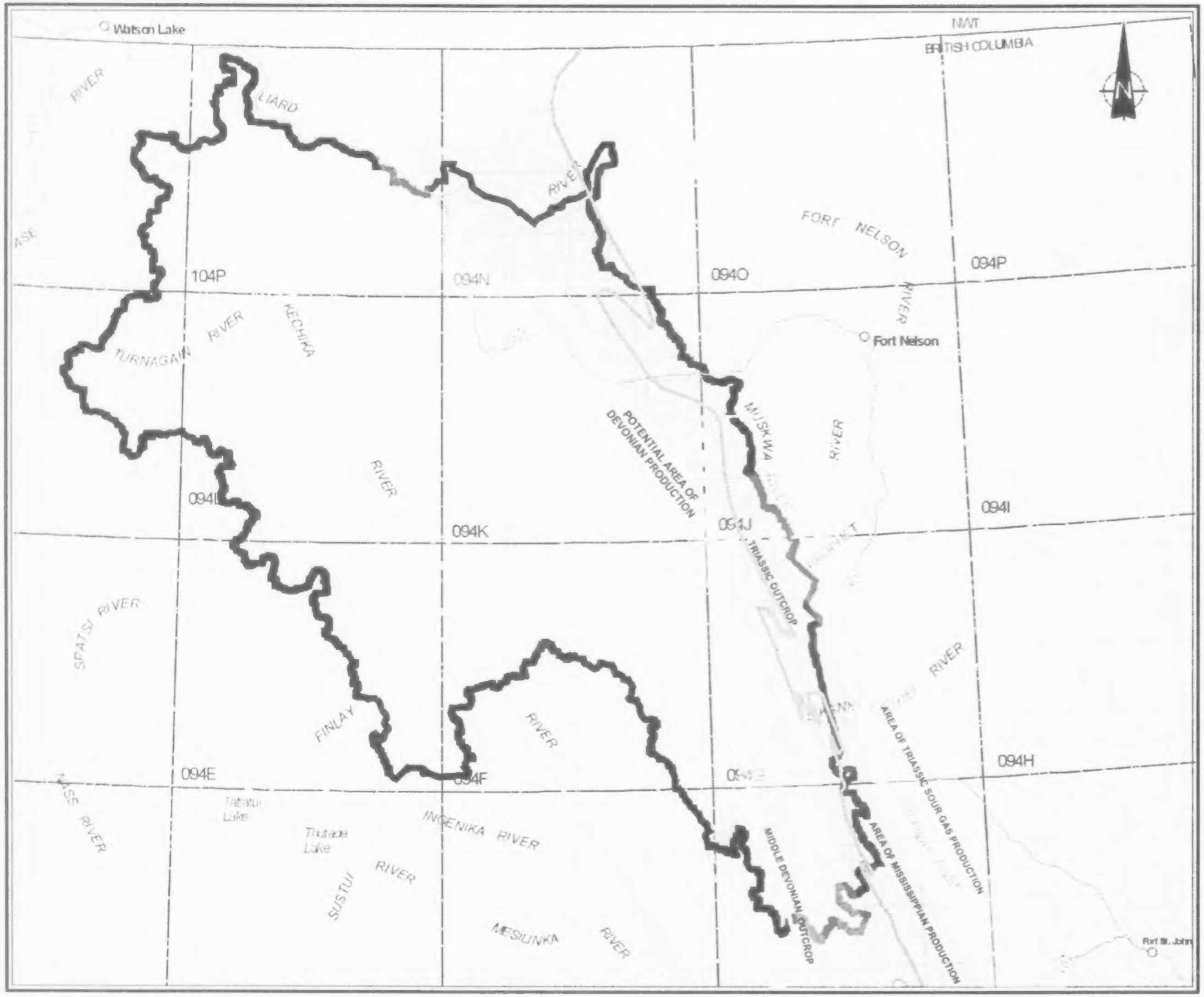

Watson Lake
NWT
BRITISH COLUMBIA
N
RIVER
LIARD
RIVER
FORT NELSON
RIVER
Fort Nelson
104P
094N
094O
094P
TURNAGAIN RIVER
KECHIKA
RIVER
MUSKWA
RIVER
POTENTIAL AREA OF DEVONIAN PRODUCTION
094L
094K
094J
094I
TRIASSIC OUTCROP
SPATSI RIVER
FINLAY
RIVER
RIVER
AREA OF TRIASSIC SOUR GAS PRODUCTION
094E
094F
094G
094H
NASS RIVER
Tatlatui Lake
Thutade Lake
INGENIKA RIVER
SUSTUT
RIVER
MIDDLE DEVONIAN OUTCROP
AREA OF MISSISSIPPIAN PRODUCTION
MESIUNKA
RIVER
Fort St. John

FIGURE 6

DISTRIBUTION OF HYDROCARBON FORMATIONS

MUSKWA-KECHIKA MANAGEMENT AREA
HELIPORTABLE DRILLING STUDY

Source: Ziebell pers. comm. 2002

Legend

Muskwa-Kechika Management Area Boundary
Watercourse
○ City or Town
Road

Hydrocarbon Formations

Main Anticlinorium of Exploration Interest
Potential Area of Devonian Production
Area of Mississippian Production
Area of Triassic Sour Gas Production
Triassic Outcrop
Middle Devonian Outcrop
SW 1/4 94J: May also have potential for "regional" Devonian (i.e. not thrusted)

Scale: 1:1,750,000

Km 0 20 40 60

(All Locations Approximate)

tera
ENVIRONMENTAL CONSULTANTS
CALGARY, ALBERTA

2555

June 2002

In most cases, the surface topographical expressions within the MK mirror the underlying "anticlinoriums" or probable hydrocarbon bearing formations. Hydrocarbons are not anticipated in the western half of the MK due to surface "breaching" of formations that may otherwise have held gas at depth.

Examination of drilling success for a number of wells in northeastern BC (Map Sheet 94G, 2,3,6,7,10,11) located west of the Alaska Highway, including a portion of the southern MK indicate that of approximately 122 wells drilled, 20 (16%) were successful, 31 (25%) were capped or shut-in, 4 (3%) were suspended and 67 (55%) were drilled and abandoned (Accumap 2002). The presence of abundant formation water in close contact with the Mississippian gas in the eastern portion of the MK has frequently resulted in wells having significant water disposal requirements and having a short production life before watering out. By comparison, drilling statistics for Alberta exploration wells in 2001 showed that of 224 oil and gas exploration wells drilled, 187 (83%) were successful (Alberta Energy and Utilities Board 2001). Depending on individual company economic analysis and the geological characteristics of a potential exploration play companies may still target rank exploration wells with probabilities of success range from 30% to 10% or less. Probability of success on rank exploration wells deeper in to the MK can be expected to likely be lower than 50%.

Significance

Drilling programs within the eastern margins of the MK will tend to encounter sweet gas at lower pressure and as such, incur lower relative risk and risk management requirements than Devonian plays to the west. However, as a matter of practice, drilling protocols in BC treat all wells as potentially sour. To the extent that a company's risk management protocol requires road access for sour gas exploratory wells, consideration or application of heliportable drilling would be restricted to easterly Mississippian formations. However, it would appear there may be somewhat greater potential for any blow-out event to include variable volumes of water and as such require an appropriate level of supervision and contingency planning. These easterly plays will tend to be shallower than those in the westerly Devonian and as such would in theory have access to a greater number of heliportable rigs. Regardless of sour gas presence, it is likely that generally larger (greater depth capability) heliportable rigs will be required for drilling targets in the western portion of the MK, though this will vary considerably with each location. As discussed in the Technical Report, larger heliportable drilling rigs are at this time, more commonly engaged outside of North America.

It is likely that drilling targets will tend to be identified on top of, or immediately adjacent to more mountainous topography, rather than in broad valley bottoms. These drilling targets will typically require more physical disturbance for conventional road accessed wells as well as potentially pose more demanding flying conditions for a heliportable operation. In either case, the constraints on the access approach will be site-specific.

It is likely that less than half the exploration wells drilled in the MK will be unsuccessful. In this context it might be argued that, barring other considerations, heliportable drilling would be more appropriate on exploration wells with less than 55% chance of success, unless environmental sensitivities were particularly high and or consideration was also being given to remote heliportable production and operation or using alternate low impact access.

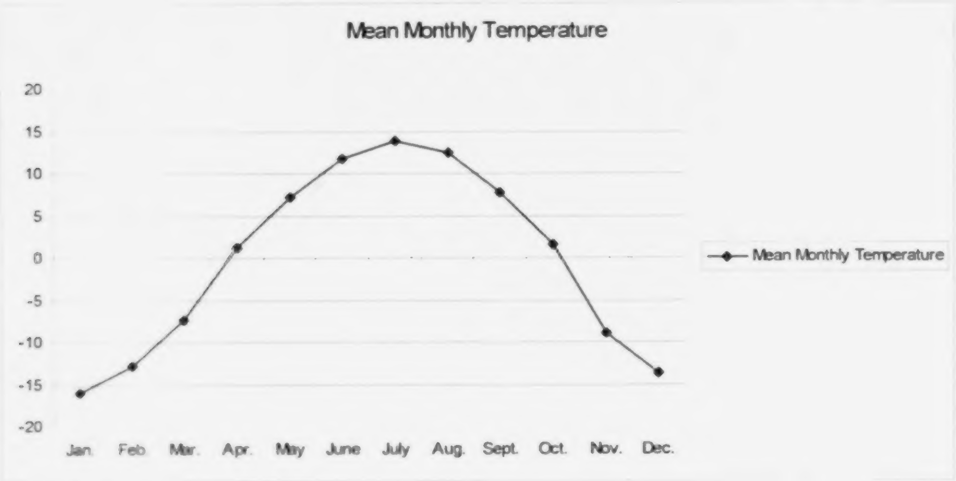
2.3 Climatic Conditions

The variability, probability and likely severity of climatic has a bearing on the conventional and heliportable operating windows, the degree of risk associated with a heliportable drilling operation and/or the need for specially equipped helicopters, flight crews and landing areas. These elements in turn have a bearing on risks, logistics (including scheduling) and costs. Severe and/or unpredictable weather conditions also has a bearing on conventional access road construction, since it affects freeze-up and the ability to build winter roads, and it may affect slope stability and erosion management along road cuts. Whether implementing a conventional drilling or heliportable drilling program, it is essential to plan for the worst weather conditions in order to provide for all contingencies to minimize risk.

2.3.1 Temperature

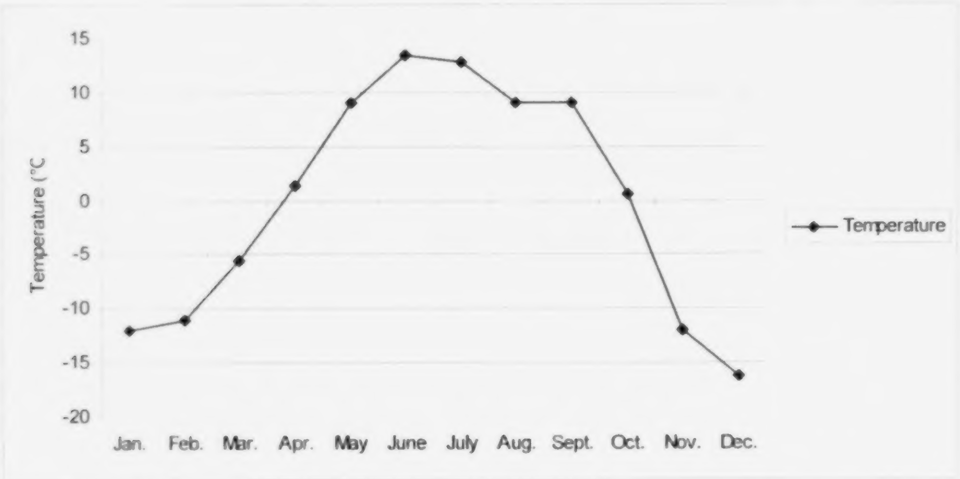
The MK is located in the rain shadow of the Rocky Mountains and is commonly under the influence of cold Arctic air in the winter (Meidinger and Pojar 1991). The area experiences relatively long, cold winters with short, cool summers. Average monthly temperatures between December and February have typically remained below -10°C while average monthly summer temperatures (June to August) have usually not exceeded 15°C (Figures 7 and 8) (Environment Canada 2002 and TERA 1996).

Mountainous topography characteristic of the area has created a variety of strong aspects where more extreme temperature conditions may prevail. These include strong south facing alpine slopes and benchlands, as well as steep north facing slopes. At Muncho Lake, the coldest average monthly temperature on record was -29.7°C and occurred in January 1982. In the last ten years, the coldest winter (December to February) recorded occurred in 1996/1997 when the average monthly temperatures ranged from -29.3°C to -8.9°C.



Source: Environment Canada 2002

Figure 7 Mean Monthly Temperatures (°C) for Muncho Lake 1970-2000



Source: TERA 1996

Figure 8 Mean Daily Temperature in Sikanni Area, 1995
(adapted from Sikanni Chief Weather Station)

Average monthly temperatures at Muncho Lake during the past 10 years (1991 to 2000) have been generally warmer than those recorded during the period from 1981 to 1990 (Table 1). However, the average monthly temperature in January during the 1991 to 2000 period was substantially colder than the average January temperature from 1981 to 1990. When comparing the last 10 years to the 30-year average for each month, most months from the 1991 to 2000 period had warmer average monthly temperatures, with the exception of January and October.

TABLE 1

AVERAGE MONTHLY TEMPERATURES (°C) FOR SELECTED PERIODS AT MUNCHO LAKE

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981-1990	-13.2	-12.8	-7.4	1.0	7.2	11.4	13.9	12.3	7.7	1.0	-10.8	-12.4
1991-2000	-17.1	-11.1	-5.6	2.0	7.7	12.5	14.3	13.0	8.3	1.3	-7.6	-12.3
1970-2000	-13.0	-12.8	-7.3	1.2	7.2	11.8	13.9	12.5	7.8	1.5	-8.9	-13.6

Source: Environment Canada 2002

Based on climatic records from Pink Mountain, frozen ground conditions (frost) have ranged from 74 days to 110 days (Table 2) (Environment Canada 1982). The first frost typically occurs in early September, though lasting frozen ground conditions may not occur until November. Mild chinook conditions can also occur later on in the winter with some potential to raise temperatures above freezing. This phenomenon is believed more pronounced in the southern half of the MK.

Further north in the MK at Muncho Lake, frozen ground conditions have ranged from 60 to 184 days (Table 2) (Environment Canada 1982). Similar to Pink Mountain, the first frost typically occurs in early September, though the date of the first frost has been recorded as early as August 4 and as late as November 1.

TABLE 2

AVERAGES AND EXTREMES DATA ON FROST EVENTS IN THE MUSKWA-KECHIKA MANAGEMENT AREA

	Pink Mountain	Muncho Lake
Latitude/Longitude	57°00'N, 122°22'W	58°55'N, 125°55'W
Metres above sea level	1204	840
Frost Event		
Averages:		
Frost Free Period (days)	88	99
Last Frost (Spring)	June 5	May 28
First Frost (Fall)	September 2	September 5
Extremes		
Longest Frost Period (days)	110	184
Shortest Frost Period (days)	74	60
Earliest Frost Period (Spring)	May 25	April 30
Latest Last Frost (Spring)	June 13	June 7
Earliest First Frost (Fall)	August 12	August 4
Latest First Frost (Fall)	September 27	November 1

Source: Environment Canada 1982

Significance

Temperature has relevance to a discussion of the feasibility of heliportable drilling in that it has a direct influence on the viability of alternate, low impact technologies dependent on low temperatures (*e.g.*, snow making, ice bridges) and on helicopter performance and operability. Helicopters have less lift capacity under warm air than in cold air due to the lower density of warm air. Temperature also interacts with moisture in the air to affect the formation of fog/cloud and the phenomenon of icing.

Under highly variable and possibly global warming trends, lower impact alternate construction practices such as the use of snow fills or ice bridges for padding and drainage crossings cannot always be relied on. Contingency measures such as the use of temporary bridges, plastic or wood matting, snow making and taking advantage of cooler night time conditions can be undertaken to offset some of these difficulties.

Under extremely cold temperatures, the initial start up and operation of heavy equipment, vehicles and helicopters are all adversely affected, though in all cases this can be managed. For helicopters, if the temperature is below -20°C, pre-heating is required for approximately 30 minutes (A-star) to 1 hour (Bell 212) for the initial start-up. Smaller helicopters such as an A-Star or Bell 206 cannot sit for more than 30 minutes at -40°C. A small 750 watt car heater can be used to preheat the engine if it has been sitting for a few hours. At temperatures between 0°C to -20°C, pre-heating is also required using a car heater. Once a Bell 212 has been in operation, it may sit for 5 to 6 hours without pre-heating. As an alternate to heated hangers, a Herman Nelson propane heating system can be used to heat a helicopter, however, this requires a person to be in full time attendance to ensure no risk of fire.

2.3.2 Fog/Low Cloud Cover

Another temperature related phenomenon of particular relevance concerns the potential and/or frequency of fog and low cloud cover resulting from the interaction of temperature and atmospheric moisture. Fog is generated more frequently in the spring and fall at times when the temperature and dew point are equal. Fog tends to be generated more commonly in areas proximate to large water bodies or wetland areas. While specific records of the occurrence of significant fog are lacking, these observations appear to hold within northeast BC. For example, it appears that in the Mackenzie District, foggy conditions are relatively more common than other locations within the MK (Adamson pers. comm.).

Fog and low visibility conditions seldom if ever last all day, although in the Fort St. John area more sustained fog can occur as a result of industrial emissions originating in the Taylor area. More typically as daytime temperatures rise sufficient to create a 1 to 2 degree difference between the temperature and dew point, foggy and cloudy conditions will tend to diminish. While in general these conditions appear to be more prevalent outside of the MK, the front ranges of this area are somewhat more prone to intense fog and low cloud cover conditions than locations further west within the MK. While relatively infrequent during periods of east wind, "upslope" conditions tend to generate fog and low stratus cloud along the front ranges of the MK. This can happen at any time of year, however they are more prevalent outside of the winter period.

Significance

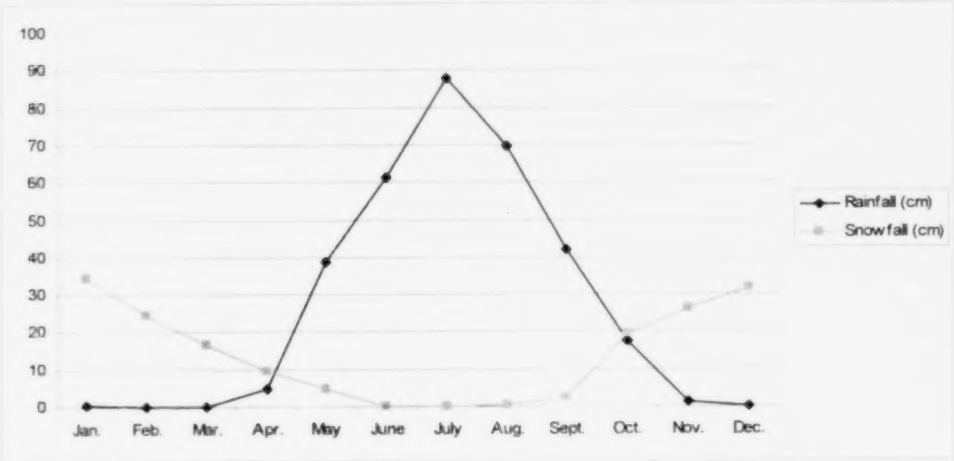
In terms of heliportable operations, Transport Canada (formerly the Department of Transportation) regulations state that unless a helicopter is specifically equipped it cannot take off under conditions in which there is 0/0 visibility (*i.e.*, there is zero horizontal and zero vertical visibility). Determining what the maximum operational limits of a heliportable drill site are to maximize the daily flight window would require a site inspection by Transport Canada (Adamson pers. comm.). In most cases, weather related "no fly" conditions do not last all day. Helicopter operation under 0/0 conditions requires the machine to be equipped for Instrument Flight Rules (IFR). This would consist of Weather Radar, Radar Altimeter, Microwave Landing System or a GPS approach system and Auxiliary Fuel Tanks. In addition, the helicopter should have a Stabilizer System (auto pilot), heated windscreen and windshield wipers. This type of operation also requires two IFR rated pilots.

In order to further manage the problems associated with poor visibility helicopter operation, there is a need to establish minimum flying altitudes on routes (*i.e.*, between the staging area and well site and between the well site and Fort St. John or Fort Nelson). These routes would be established in advance. In a similar way, in order to manage an emergency helicopter evacuation in the mountains under foggy/low cloud cover conditions, the pilots would typically pre-plan a group of alternate evacuation routes that would either place them well above the highest mountain peaks in "clean air" (low turbulence) to ensure safety or provide for valley bottom access. Transport Canada guidelines state the aircraft must be 610 m (2,000 ft) above the highest peak within 16 km (10 miles) on either side of the center line of the flight (Transport Canada 2001). Within the MK, this can range from 2,440 m to 3,050 m (8,000 ft to 10,000 ft), although peak heights in the eastern areas are considerably less.

If using the Instrument Flight Rules to plan around weather, it is essential to have a reliable phone connection in order to monitor and report weather conditions that may be developing. Such systems are already part of routine drilling programs in the MK.

2.3.3 Precipitation and Icing

Most precipitation in the MK falls as rain (Figures 9 and 10). Within the MK, mean annual precipitation is 494 mm with most rain falling between June and August (Environment Canada 2002). The number of days in which rain and snow fell in Muncho Lake by month over the last five years (1996 to 2000) and over the period from 1991 to 1995 is summarized in Table 3. More rainfall and snowfall occurred during the period from 1991 to 1995 than in the most recent five years of record.



Source: Environment Canada 2002

Figure 9 Mean Monthly Precipitation for Muncho Lake 1970 to 2000

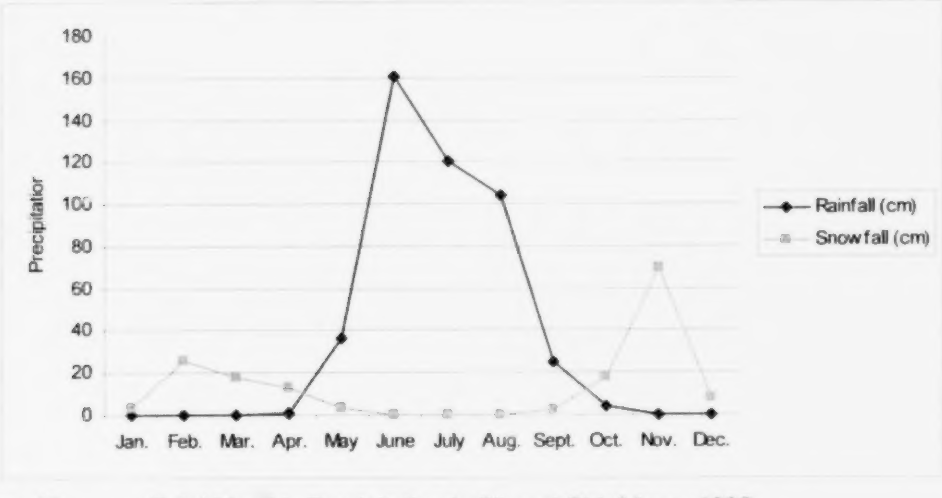


Figure 10 Total Monthly Precipitation in Sikanni Chief Area, 1995 (adapted from Sikanni Chief Weather Station)

TABLE 3

AVERAGE MONTHLY TOTAL RAINFALL, TOTAL SNOWFALL AND TOTAL PRECIPITATION VALUES FOR MUNCHO LAKE FOR SELECTED PERIODS

	1991-1995			1996-2000		
Month	**Rainfall (mm)**	**Snowfall (cm)**	**Total Precip. (mm)**	**Rainfall (mm)**	**Snowfall (cm)**	**Total Precip. (mm)**
Jan	0.0	32.2	32.2	0.0	38.6	38.6
Feb	0.0	23.4	23.4	0.0	18.4	18.4
Mar	0.2	15.5	15.7	0.0	20.4	20.4
Apr	8.2	5.4	13.6	7.7	9.6	17.3
May	40.3	0.2	40.5	37.3	5.8	43.1
Jun	62.6	0.0	62.6	60.8	0.0	60.8
Jul	82	0.0	82	90.4	0.0	90.4
Aug	70.2	0.6	70.8	78.8	0.0	78.8
Sep	42	4.2	46.2	42.7	3.7	46.4
Oct	25.3	10.9	36.3	9.1	18.3	27.4
Nov	0.5	39	39.5	0.4	16.8	17.2
Dec	0.0	38.9	38.9	0.0	28.6	28.6

Source: Environment Canada 2002

In the MK, precipitation events which most commonly occur in the spring and early summer can combine with cooler temperatures to create "socked-in" conditions where there is heavy fog and low cloud cover, particularly at higher elevations (Plate 2). The MK is notable in the periodic occurrence of exceptionally heavy rain events or cloud bursts in late spring and early summer. For example, between July 14 and 19, 1996 a total of 145 mm (5.7 inches) of rain fell in the Sikanni Chief area (TERA 1996). In the late spring and summer of 2001, particularly heavy rainfall resulted in high, flash flood events on drainages within the area. Most snowfall occurs between October and March. Snow accumulations may be quite variable from year to year. In January 1996, 99 cm of snow fell in a 48-hour period (TERA 1996).

Plate 2 Example of "socked-in" conditions with heavy fog and low cloud cover.

The phenomenon of "icing" refers to the circumstance whereby temperature and atmospheric moisture are such that surface temperatures on aircraft wings or helicopter rotors are cooler than the surrounding air, with the result that atmospheric moisture condenses and freezes on these surfaces. Icing can occur at any time of year when there is higher, warmer moist air interfaced with a lower cold air mass. It is less frequently associated with summer than winter due to temperature, however "icing" can occur at anytime of the year depending on combined temperature and moisture effects.

Significance

The relatively low snow levels and moderate winter temperatures characteristic of the area is in part responsible for the high ungulate abundance and diversity associated with the area.

Periods of heavy rain and/or rapid snow run-off, as can occur in the MK, increase the probability of wet weather shut down during road construction. These same conditions also place particular emphasis on the need for effective erosion control and tend to favor winter construction and drilling programs where there is an interest in minimizing soil disturbance.

For heliportable operations, pilots typically avoid flying through very intense rain or snow storms wherever possible due to the lack of visibility. Precipitation events in the MK can be associated with conditions that affect the ability to operate helicopters. For example, it is more common to have "socked-in" conditions during periods of cool temperatures and high rainfall in the early summer. During periods of intense snow flurries, visibility can also become so limited as to create no-fly conditions unless the helicopter is IFR equipped.

Another aspect of heliportable operations influenced by precipitation and also dust, is the relatively greater occurrence for potentially lethal static electricity discharge when slinging loads during fine snow or dust conditions using large machines.

An interesting aspect of the relatively low levels of snow fall and winter precipitation in much of the MK combined with surficial geology and land form features, is the tendency of certain drainage systems to exhibit surface flow only during spring to early to mid-summer. At the same time, the common presence of sub-surface spring flows in these settings can result in gradual build up of ground fast ice and overflow with the end result being creation of broad ice sheets on the drainage during winter. It is this phenomenon that in part allowed Murphy Oil Company Ltd. to construct a low impact temporary access road to their well sites in the Chicken Creek valley in the southern portion of the MK (Plates 3 and 4). Similar opportunities occur elsewhere in the MK.

Icing conditions can represent a serious threat to the safe operation of helicopters and other aircraft. Transport Canada regulations forbid flying aircraft not equipped with de-icing capability during known icing conditions (Transport Canada 2001). Helicopters with de-icing capability (heated rotors, de-icing boots on the rotors) such as the Cormorant are not presently available for non-military use.

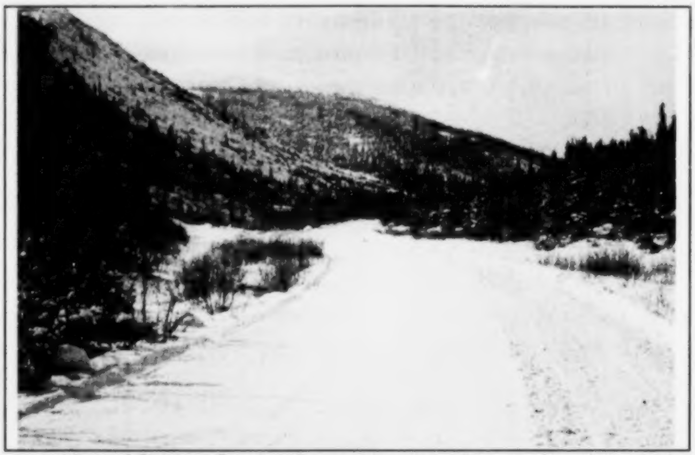


Plate 3 View of Chicken Creek valley and low impact ice road to winter exploration well site. (Photo courtesy of Kaizen Environmental Services Inc.)

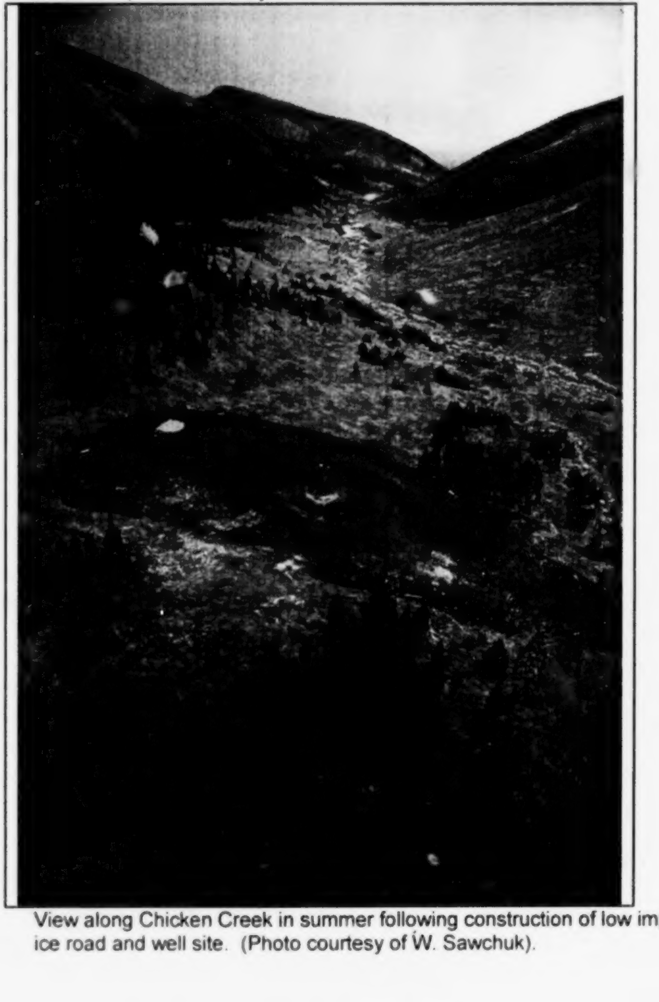


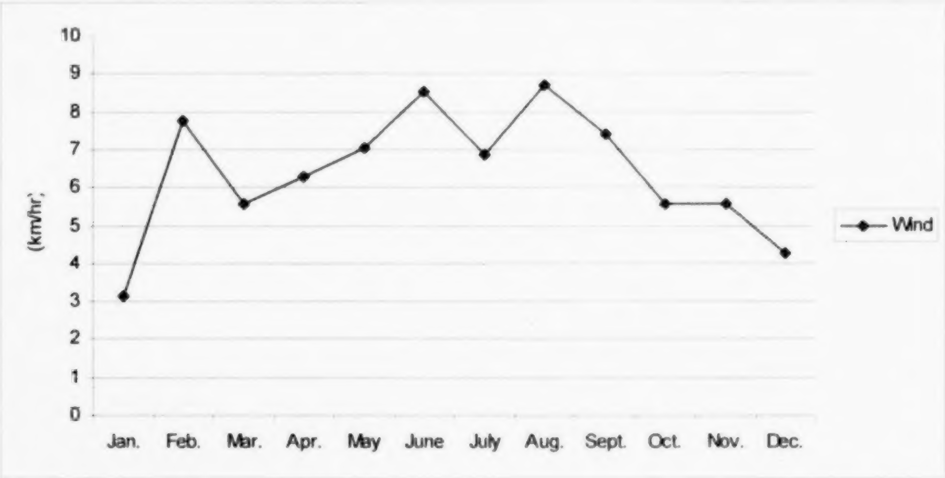
Plate 4 View along Chicken Creek in summer following construction of low impact ice road and well site. (Photo courtesy of W. Sawchuk).

Within the Fort St. John area, there may be perhaps 14 days over the course of a year, where parts of a given day (*e.g.*, a few hours) are considered no-fly conditions due to the risk of icing. The actual number of days where these conditions occur varies from year to year. Within the MK, the risk of icing during parts of a given day may increase on mountain tops or higher elevation to approximately 30 days.

2.3.4 Wind

Winds in the MK are predominantly from the west and southwest throughout the year. This results in more laminar air flow along east-west valleys (*e.g.*, Chowade, Halfway, Sikanni, Buckinghorse river valleys) and leads to a combination of turbulence and downdrafts on the west side of north-south valleys and updrafts on the east side of such valleys. There are often strong updrafts on south facing slopes due to convection, and downdrafts on the lee sides of mountains and around glaciers.

During 1995, the average mean monthly wind speed in the Sikanni Chief area ranged from 3.1 km/hr in January to 8.6 km/hr in August (Figure 11). Maximum wind speeds in excess of perhaps 100 km/hr may be encountered. Strongest winds typically occur during the summer and fall. Higher winds and turbulence are more often encountered at higher elevations in proximity to alpine ridgelines and basins, as opposed to broad valley bottom locations. Wind conditions may be highly variable from year to year.



Source: TERA 1996

Figure 11 Mean Monthly Wind Speed in Sikanni Chief Area, 1995 (adapted from Sikanni Chief Weather Station)

A province-wide assessment of wind energy potential was conducted by TrueWind Solutions on behalf of BC Hydro in 2000, and provides some insight into the distribution of areas within the MK which tend to have higher average wind velocities (BC Hydro 2001). A wind energy resource map was created and displays annual average wind speeds at a height of 65 m above the ground (Figure 12).

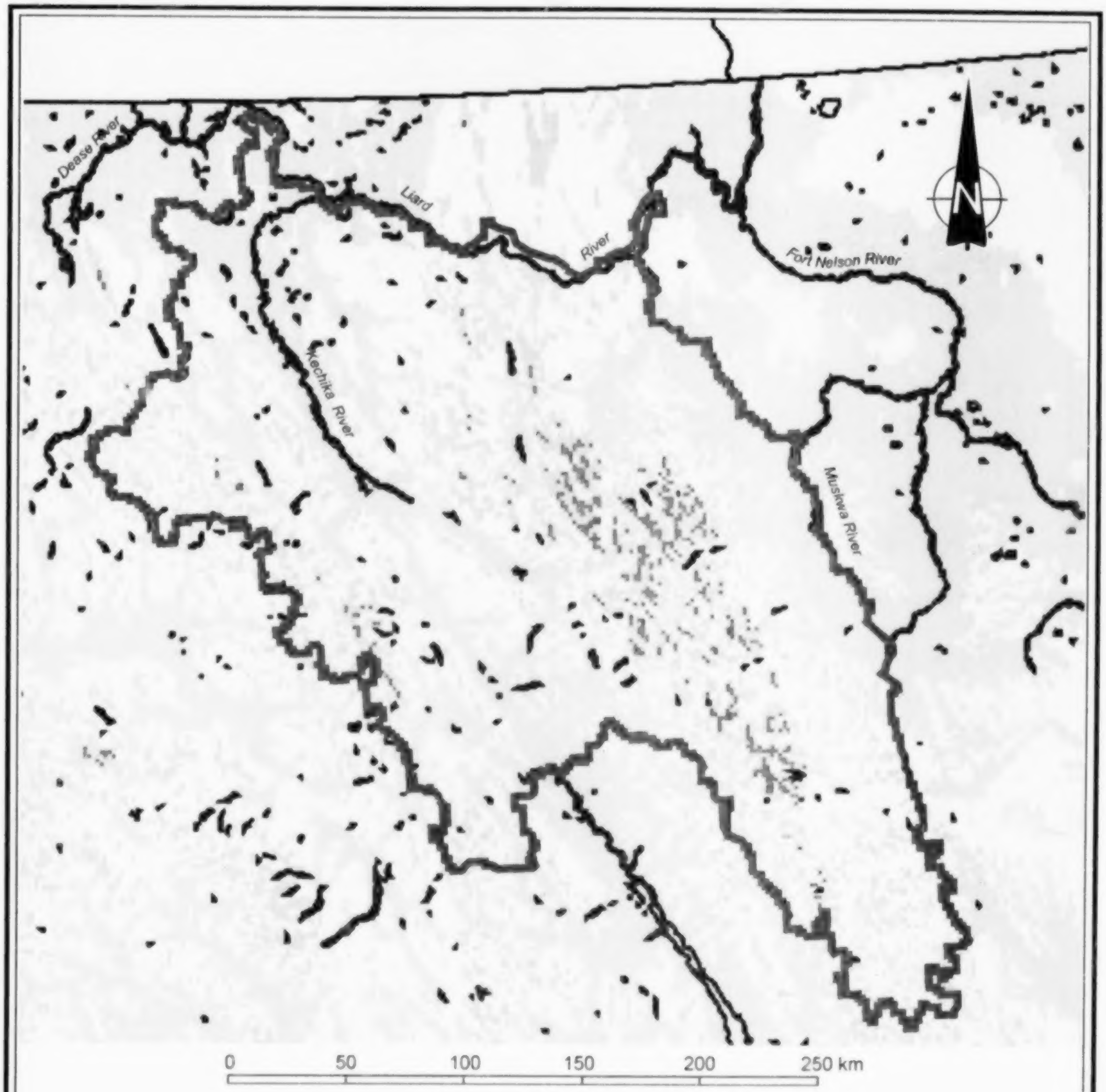
The wind energy resource map provides annual average model predicted wind speeds, and identifies some of the highest wind areas as being associated with the Northern Rocky Mountains; Kwadacha Wilderness area; the Redfern-Keily area; Muncho Lake; an elliptical area extending south from Muncho Lake Park to the Kwadacha Wilderness Park; and a narrow band of high elevation areas along the western border of the MK. Monitoring is required to identify the true resource, seasonal variability and the consistency of the wind in site-specific areas.

Significance

Wind and associated turbulence has a strong influence on helicopter performance and maneuverability and tends to exert a greater constraint on smaller helicopters than larger helicopters. Wind does not influence the amount of weight a helicopter can pick-up. Some wind can facilitate the ease with which loads are picked up, while turbulence or more gusty or erratic wind conditions can interfere with load pick-up and drop-off. This latter situation can require the need for more intensive ground control by riggers or lead to no-fly conditions. Periods of no-fly conditions due to excessive wind would have a bearing on the time required to mobilize and demobilize a drilling rig, as well as on the ability to provide a heliportable rig with on demand service.

For A-Stars, wind above 50 km/hr, with accompanying high turbulence are difficult conditions to fly in. Wind in the MK might be expected to shut-down flying by such smaller helicopters during parts of a given day for perhaps a 14 day spread over the course of a year (location, season and year dependent) (Adamson pers. comm.). For larger helicopters such as a Bell 212 or Sikorsky S-61, conditions involving 90 km/hr winds and extreme turbulence could lead to shut down for parts of a given day, though machines such as the Bell 212 have been operated in emergency situations where wind gusts exceeded 100 km/hr. Larger machines may be shut-down for two to three days a year in valley bottoms, and up to seven days a year in alpine areas. Such shut-downs would typically not last more than a few hours. It can still be anticipated that rig mobilization using a helicopter may encounter periodic delays depending on well site location and wind conditions. Routine well servicing during the actual drilling operation would be unaffected.

Figure 12 Wind Energy Resource Map


Dease River
Liard River
Fort Nelson River
Kechika River
Muskwa River
N
0
50
100
150
200
250 km

Projection: Universal Transverse Mercator (Zone 9)
Spatial Resolution of the Wind Resource Data: 1000m

This wind resource map of British Columbia was developed for BC Hydro by TrueWind Solutions using the MesoMap system - a dynamic atmospheric simulation model - and historical weather data.

This map was generated using mathematical models and illustrates general wind velocities for information purposes only. Wind speed and direction may vary. Consult a qualified professional before relying on the information expressed on this map.

Legend

— Muskwa-Kechika Management Area Boundary

— Waterbody

(Annual Average Wind Speed (m/s)

- □ <4 m/s
- □ 4 to 6 m/s
- ▒ 6 to 8 m/s
- ▓ >8 m/s

(All Locations Approximate)

FIGURE 12

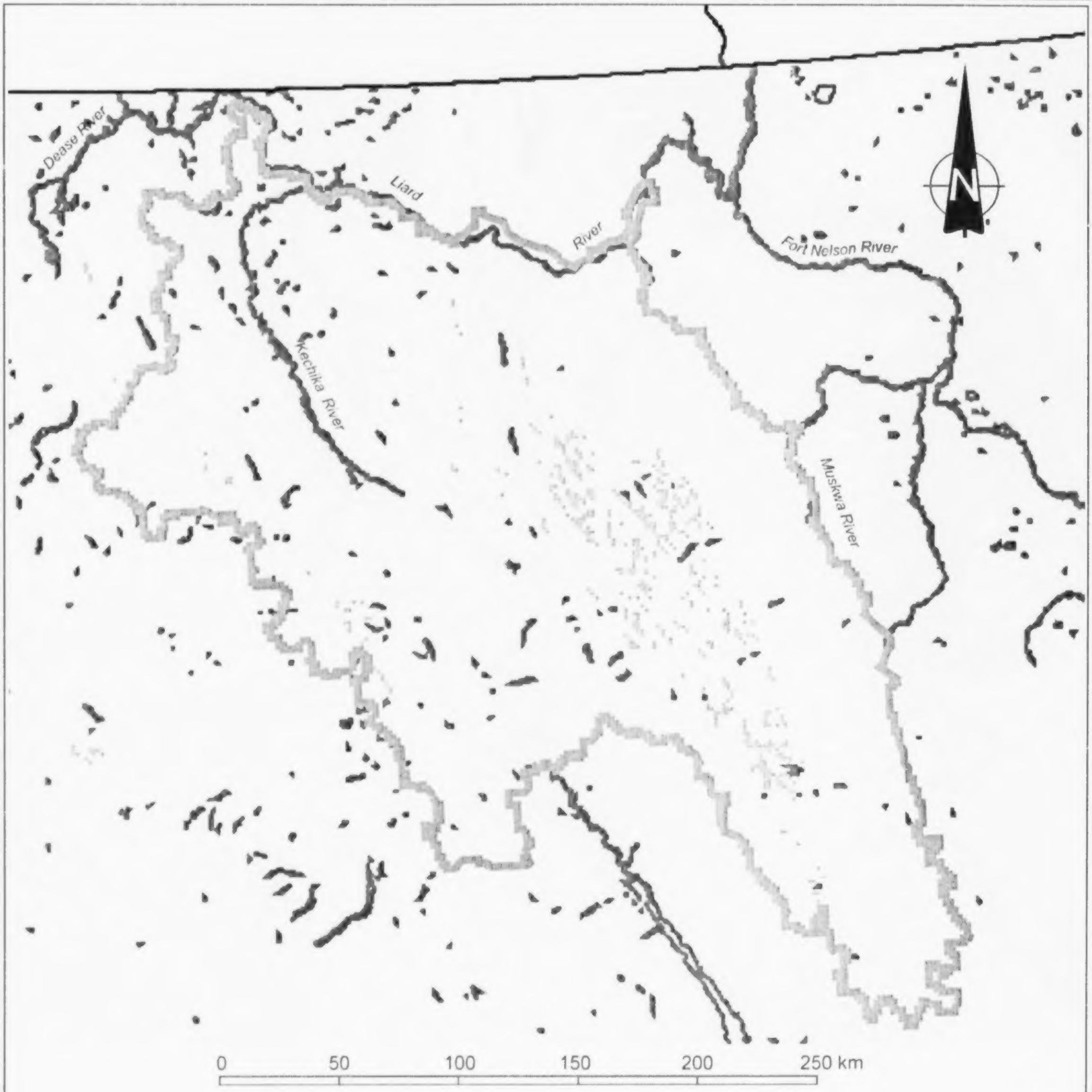
WIND ENERGY RESOURCE MAP

MUSKWA-KECHIKA MANAGEMENT AREA HELIPORTABLE DRILLING STUDY

Adapted from BC Hydro 2000

2555

June 2002


Dease River
Liard River
Fort Nelson River
N
Kechika River
Muskwa River
0
50
100
150
200
250 km

Projection Universal Transverse Mercator (Zone 9)
Spatial Resolution of the Wind Resource Data 1000m

This wind resource map of British Columbia was developed for BC Hydro by TrueWind Solutions using the MesoMap system - a dynamic atmospheric simulation model - and historical weather data

This map was generated using mathematical models and illustrates general wind velocities for information purposes only Wind speed and direction may vary Consult a qualified professional before relying on the information expressed on this map

Legend

Muskwa-Kechika Management Area Boundary

Waterbody

(Annual Average Wind Speed (m/s)

- <4 m/s
- 4 to 6 m/s
- 6 to 8 m/s
- >8 m/s

(All Locations Approximate)

FIGURE 12

WIND ENERGY RESOURCE MAP

MUSKWA-KECHIKA MANAGEMENT AREA HELIPORTABLE DRILLING STUDY

Adapted from BC Hydro 2000

2555

June 2002

From a wind perspective, broad valley bottoms, particularly where these have an east-west orientation are the most preferred locations for a well site. Within alpine settings, more favorable wind conditions are associated with broad, flat alpine areas compared to sharp ridges, points or basins/cirques. A heliportable well location along the leeward side of a north-south valley would be exposed to more frequent down draft phenomenon which would have a higher frequency of no-fly conditions for the purpose of slinging equipment or supplies. Normal flight planning around daily weather conditions at such sites can be expected to largely eliminate potential for emergency load or release.

2.3.5 *Heliportable Well Site Location and its Relationship to Climatic Concerns*

Considering the influence of topography on climatic conditions in the MK, it is apparent that more helicopter operational challenges would be encountered when trying to service a heliportable well site on top of a mountain as opposed to broad valleys due to problems associated with fog, cloud cover, icing and wind and their greater probability of occurrence at higher altitude. Locations close to the more easterly "front ranges" can be expected to experience somewhat greater frequency of poor flying conditions at certain times of the year due to the tendency for fog build-up in this area. Heliportable well locations in narrow north-south valleys, particularly the west side of such valleys would also be less favorable from a flying perspective. Elevations rise up to the west and north central end of the MK implying that northwestern areas may present somewhat more challenging circumstances for heliportable operations for the previously stated reasons just as they do for conventional road access development.

As previously discussed, problems associated with visibility can be managed by using a properly trained and equipped crew, helicopters and landing systems. However, it must also be recognized that there are other environmental considerations around both conventional and heliportable drilling alternatives in high elevation alpine areas (*e.g.*, reclamation challenges, wildlife impacts). At a given temperature, more favorable helicopter lift capability is also encountered at lower elevations, though the magnitude of this effect does not appear to be a significant consideration given the elevations encountered in the MK and also keeping in mind altitude related temperature effects on air density.

Shortening the distance between the well site and nearest vehicle access staging area would also tend to reduce overall climate-related flying risks or challenges associated with a heliportable operation. Similarly, if the drilling camp is located near the well site there is also less potential interference on heliportable operation by weather.

Poor weather conditions also have a bearing on the time taken to sling loads, which in turn has a potentially significant bearing on helicopter costs. As a matter of standard practice, pilots slinging heavy loads will be inclined to sling via the shortest route. This reduces flying time and potential for weather conditions to interfere with the operation. Localized weather conditions associated with certain higher elevation mountainous landforms may still require more circuitous routes as may other sensitivities (*e.g.*, presence of occupied critical sheep or mountain goat range)

2.4 Day Length

Seasonal variation in day length recorded at Muncho Lake within the MK is presented in Table 4. There is a maximum of 21.1 hours of day length (hours of day illumination plus hours of sky illumination) from June 16 to June 26 and a minimum of 8.1 hours of day length from December 16 to December 26. Between March 2 and October 10, there is at least 12 hours of total illumination per day while at least 12 hours of day illumination occurs from March 18 to September 24. Peak hours of day illumination occurs from June 19 to June 22 at 18.48 hours (National Research Council of Canada 2002).

TABLE 4

DAY LENGTH AT MUNCHO LAKE

Month	Average Hours of Day Illumination/Day	Average Hours of Sky Illumination/Day	Total Average Hours of Illumination/Day
January	7.13	1.6	8.8
February	9.33	1.42	10.7
March	11.87	1.35	13.2
April	14.52	1.5	16
May	16.95	2.02	19
June	18.34	2.74	21.1
July	17.62	2.3	19.9
August	15.38	1.63	17
September	12.8	1.36	14.2
October	10.19	1.37	11.6
November	7.75	1.57	9.3
December	6.35	1.78	8.1

Source: National Research Council of Canada 2002

Significance

Day length affects the duration of Visual Flight Rules (VFR) conditions for conventional helicopter flying. Typically helicopters with VFR rating are allowed to fly from 30 minutes before sunrise to 30 minutes after sunset. VFR pilots must have visual contact with the ground. From this perspective, the summer (May through September) provides a better operating window for conventional helicopter operation than winter (Adamson pers. comm.).

Extending operations (for example to allow 24-hour helicopter rig servicing) beyond these periods requires specialized certification and equipment. Nighttime heavy-lift and transport helicopter operations were routinely conducted out of Tuktoyaktuk in the Canadian Beaufort Sea area through the 1980's (Adamson pers. comm.).

2.5 Vegetation

The MK encompasses portions of the Alpine Tundra, Spruce-Willow-Birch and Boreal White and Black Spruce Biogeoclimatic Zones (Meidinger and Pojar 1991). Alpine Tundra is dominated by dwarf shrubs, herbs, mosses and lichens. The Spruce-Willow-Birch zone occurs at moderate elevations in the MK and includes open spruce and fir dominated forests, willow and scrub birch communities, grasslands and sedge dominated wetlands. The Boreal White and Black Spruce zone occurs at lower elevation valley bottom sites and vegetation includes extensive aspen, pine and spruce forests as well as black spruce bogs. The general distribution of these communities is presented in Figure 13. Broad vegetation zones have been identified as part of the Upper Sikanni and the Besa-Prophet Pre-Tenure Management Plans. Most forested areas are of an open forest type with relatively short trees.

Significance

Vegetation has a bearing on the environmental feasibility or desirability of heliportable drilling in several ways.

Alpine tundra vegetation is highly sensitive to disturbance and is very slow to re-establish once disturbed. Unless alpine terrain is very gentle, low impact road construction (*e.g.*, using snow fill or other padding) is not possible. In this context, relatively greater impacts will occur using conventional road access compared with heliportable. Where there is a requirement to more aggressively reclaim and monitor alpine reclamation, a company could encounter potentially significant manpower and financial commitment.

In a similar way, new road construction through forests within the MK would inevitably result in creation of a scar in the vegetation mosaic with attendant impact on the wilderness landscape aesthetic associated with the area. These impacts would not be encountered on a heliportable operation. Again, where there is a requirement to fully reclaim such forested areas through silvicultural means (*e.g.*, reforestation, transplants) additional manpower and costs would be encountered relative to a heliportable operation or situations where the company was only required to control erosion and re-establish grass cover.

The presence of valley bottom areas dominated by willow, dwarf/scrub birch and/or meadows provides some opportunity for low impact road construction as an alternative to a heliportable operation. These vegetation communities provide the opportunity for construction of temporary winter access by walking over the vegetation and building snow/ice roads (with or without mowing) with potentially only minor impact to the landscape aesthetic and functional integrity of the affected vegetation communities. This latter approach was used by Murphy Oil Company in the Chicken Creek valley in the southern portion of the MK with good success.

Figure 13 Vegetation Communities

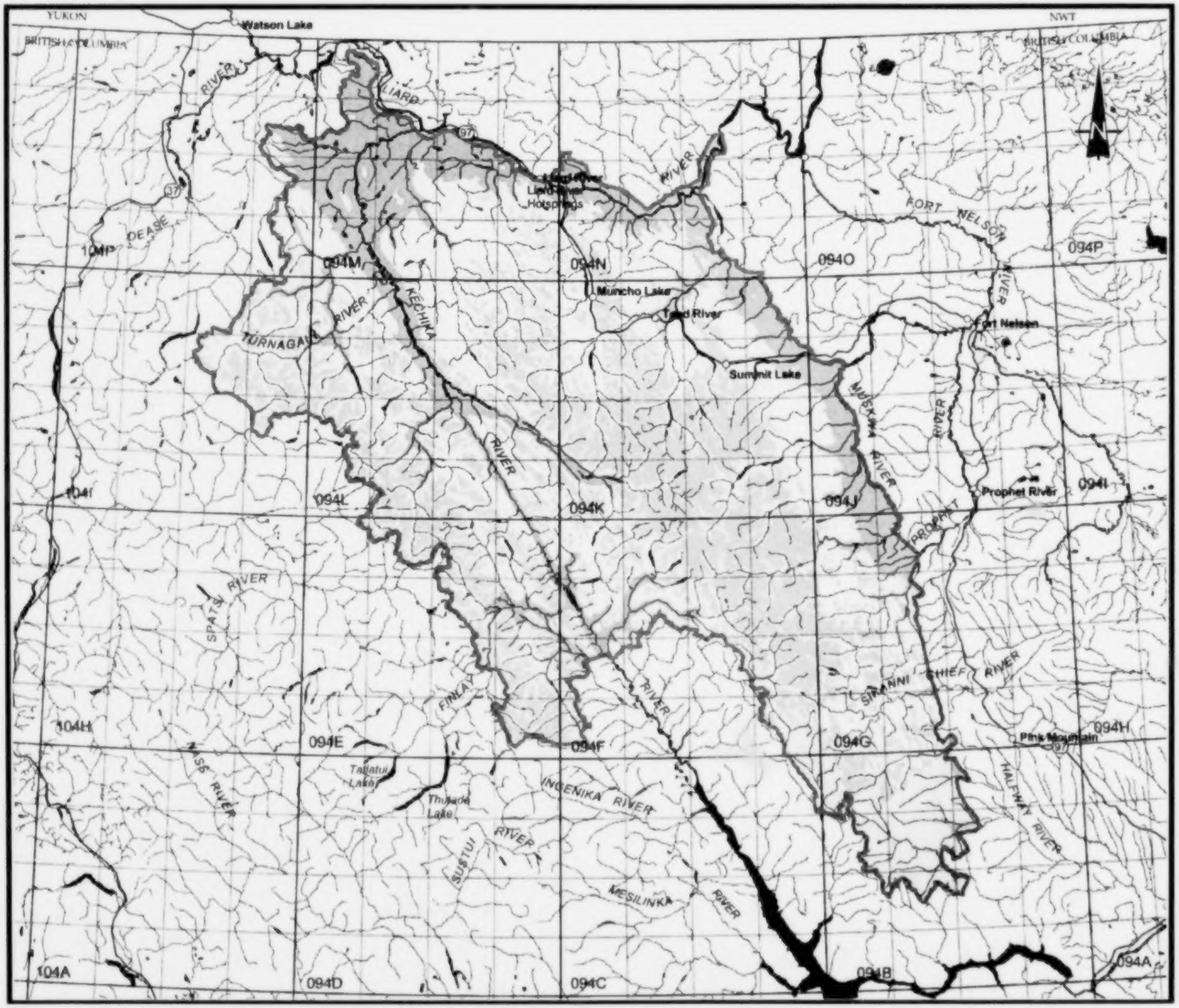

YUKON
BRITISH COLUMBIA
Watson Lake
NWT
BRITISH COLUMBIA
LIARD
RIVER
97
37
DEASE
RIVER
104P
094M
094N
094O
094P
Liard River
Liard River Hotsprings
Muncho Lake
Toad River
Summit Lake
Fort Nelson
FORT NELSON RIVER
RIVER
TURNAGAIN RIVER
KECHIKA
RIVER
MUSKWA RIVER
PROPHET
RIVER
Prophet River
104I
094L
094K
094J
094I
SPATSIZI RIVER
FINLAY
RIVER
SIKANNI CHIEF RIVER
104H
094E
094F
094G
094H
Pink Mountain
97
Tatlatui Lake
Thutade Lake
NASS RIVER
INGENIKA RIVER
SUSTUT RIVER
MESILINKA RIVER
HALFWAY RIVER
104A
094D
094C
094B
094A
N

FIGURE 13

VEGETATION

MUSKWA-KECHIKA MANAGEMENT AREA
HELIPORTABLE DRILLING STUDY

LEGEND

- Muskwa-Kechika Management Area Boundary
- ○ City
- Major Road
- Major Watercourse
- ▨ Waterbody
- ☐ 1:250,000 map sheet grid

Vegetation

- ALPINE TUNDRA
- BOREAL SUBALPINE
- FOOTHILLS BOREAL
- INTERIOR ALPINE
- INTERIOR SUBALPINE FOREST
- MOUNTAIN BOREAL
- SUB BOREAL SPRUCE

Sources

Muskwa Kechika Management Area Boundary
BC Ministry of Sustainable Resource Management 2000
Hydrology: © 2000. Government of Canada with
permission from Natural Resources Canada.
Vegetation: BC Ministry of Sustainable Resource Development 2002
(http://srmwww.gov.bc.ca/rib/wis/bec/bec_data.htm)

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of the data are advised that errors in the data may be present.

SCALE: 1:1,750,000

Kilometres

(All Locations Approximate)

CALGARY ALBERTA

June 2002

2556

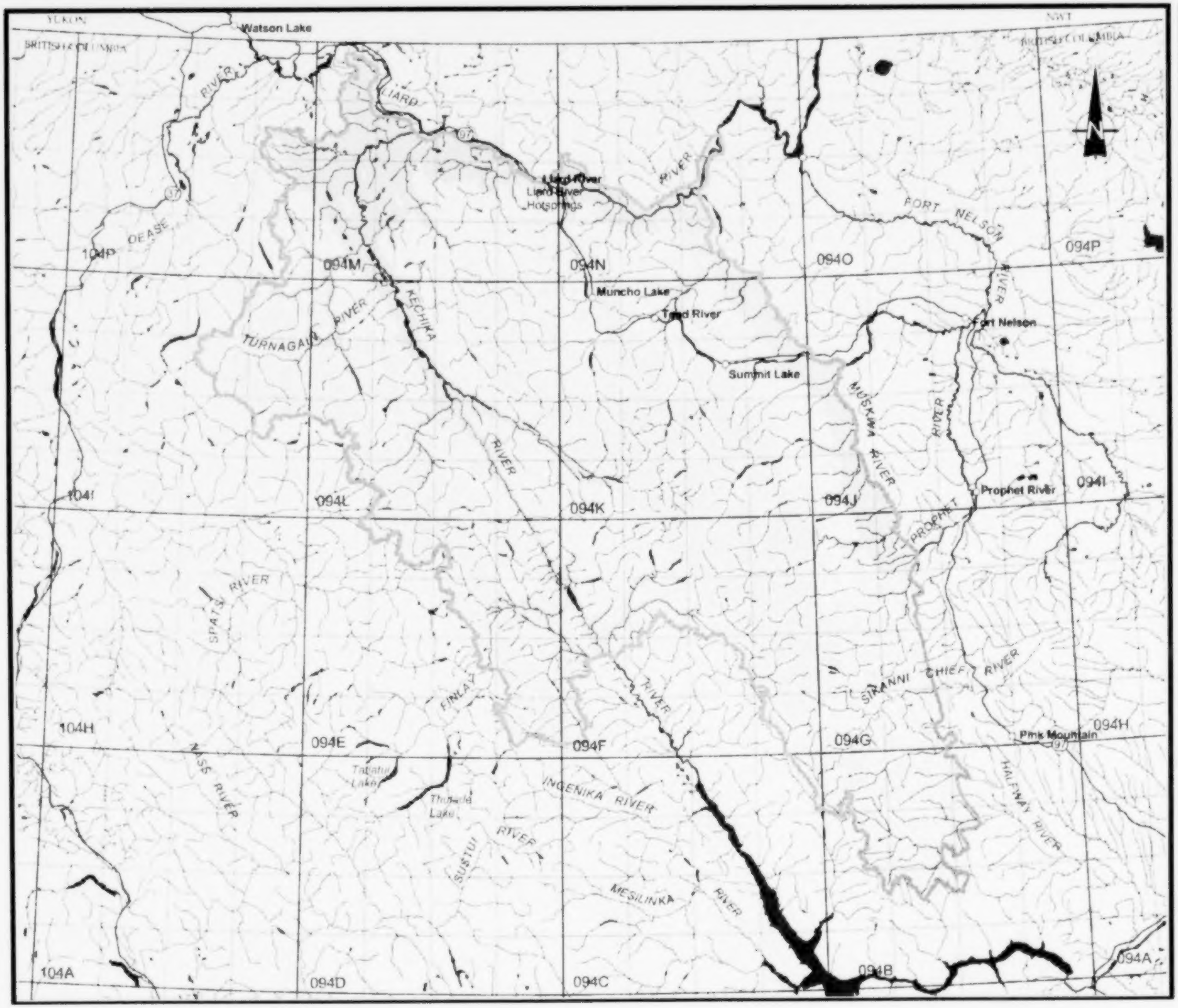

YUKON
BRITISH COLUMBIA
Watson Lake
NWT
BRITISH COLUMBIA
N
RIVER
LIARD
37
97
Liard River
Liard River Hotsprings
RIVER
FORT NELSON
RIVER
DEASE
37
104P
094M
094N
094O
094P
Muncho Lake
Toad River
Fort Nelson
KECHIKA
TURNAGAIN RIVER
Summit Lake
MUSKWA RIVER
RIVER
RIVER
104I
094L
094K
094J
Prophet River
094I
PROPHET
SPATSIZI RIVER
RIVER
SIKANNI CHIEF RIVER
FINLAY
104H
094E
094F
094G
Pink Mountain
97
094H
Tatatui Lake
Thutade Lake
INGENIKA RIVER
NASS RIVER
SUSTUT RIVER
HALFWAY RIVER
MESILINKA
RIVER
104A
094D
094C
094B
094A

FIGURE 13

VEGETATION

MUSKWA-KECHIKA MANAGEMENT AREA
HELIPORTABLE DRILLING STUDY

LEGEND

▬	Muskwa Kechika Management Area Boundary
○	City
—	Major Road
	Major Watercourse
▭	Waterbody
	1:250,000 map sheet grid

Vegetation

- ALPINE TUNDRA
- BOREAL SUBALPINE
- FOOTHILLS BOREAL
- INTERIOR ALPINE
- INTERIOR SUBALPINE FOREST
- MOUNTAIN BOREAL
- SUB BOREAL SPRUCE

Sources

Muskwa Kechika Management Area Boundary
BC Ministry of Sustainable Resource Management 2000
Hydrology: © 2000. Government of Canada with
permission from Natural Resources Canada
Vegetation: BC Ministry of Sustainable Resource Development 2002
(http://srmwww.gov.bc.ca/ecology/bei/base_data.html)

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of this data are advised that errors in the data may be present.

SCALE: 1:1,750,000

(All Locations Approximate)

June 2002

2555

2.6 Fish and Aquatic Ecosystems

The numerous rivers, creeks and lakes within the MK support a relatively productive but sensitive cold water fishery for rainbow trout, bull trout, arctic grayling and many other fish species. Common objectives of the LRMPs that lie within the MK are to maintain water quality, protect the habitats required by fish and to identify and map critical fish habitat (Fort St. John LRMP 1997, Fort Nelson LRMP 1997, Mackenzie LRMP 2000).

Significance

As is the case for wildlife, creation of new unregulated or poorly regulated access creates potential for increased vulnerability of fish and aquatic ecosystems from legal and illegal fishing and erosion and also begs a greater enforcement effort to attempt to manage such harvest. Road crossings of water bodies quickly become focal points for fishing pressure and access to nearby streams and lakes. Probably the greater concern within the MK, however, relates to the potential and inevitable occurrence of long-term erosion and siltation caused by most road development (some winter roads largely avoid this).

A relatively contemporary and thorough overview of research into the impacts of roads on fish and fish habitat as well as vegetation and wildlife was prepared by Higgins (2001) with funding from the Muskwa-Kechika Trust Fund. Further discussion of the nature of road impacts on fish and aquatic ecosystems is included in Section 3.1.

The presence of high value and relatively high sensitivity fishery resources within the MK increases the need for fisheries specific research, planning, design, compensation (see Section 35(2) of the *Fisheries Act*) and permitting where it involves conventional road construction. Heliportable access eliminates potential impacts caused by erosion, riparian habitat loss, and human fishing pressure to fish and aquatic ecosystems associated with more conventional road access as well as the costs and time associated with assessment and planning around these. Potential for spills during fuel hauling can arise with both conventional road accessed drilling programs as well as for heliportable drilling programs. No attempt at quantifying this risk has been made, however, in both cases it is believed to be low.

2.7 Critical Wildlife Habitat

As mentioned at the outset, the MK supports a number of highly valued wildlife species. In most cases, species select different habitat types depending on the season as well as hunting pressure by predators and humans. While Stone's sheep and mountain goat are most typically associated with higher elevation alpine sites within the MK, other large mammals may range from open alpine sites to forested valley bottom locations.

Critical wildlife habitat refers to those areas that for one or more reasons, tends to concentrate certain wildlife species, provide an essential item or items for the species survival (*e.g.*, food/nutrients, thermal cover, predator avoidance), and are not broadly distributed across the landscape. It could be argued that all the habitat used by a species is in some sense critical or being used for non-trivial reasons, however, for the purpose of practical habitat management, resource managers have often been forced to prioritize species habitats. In this regard, features such as mineral licks, warm aspect grasslands, sheep and goat wintering range, sheep lambing areas, and lowland shrub willow communities are among the more definable site types frequently identified as Critical Wildlife Habitat. These sites have not been exhaustively inventoried and wildlife habitat mapping for the MK area is only available at a working scale in the Besa Prophet Pre-tenure Plan area. Regional wildlife habitat mapping has been completed for parts of northeastern British Columbia as part of the Northeastern BC Biophysical Mapping Project (BC MELP 1999). Habitat classifications are based on assessment of habitat suitability (*i.e.*, the current suitability of the area to support wildlife) and are mapped at a scale of 1:250,000. Available mapping of critical wildlife areas within the MK, including known Stone's sheep and mountain goat range is presented in Figures 14 and 15.

Significance

Projects that require the creation of significant new access in close proximity to areas identified as Critical Wildlife Habitat will tend to result in greater impacts to wildlife productivity within the MK. Any new conventional access through or close to such areas has the potential to directly impact habitat supply and facilitate hunter and predator access (James and Stuart Smith 2000). Immediate and prompt reclamation and use of extensive rollback can reduce these latter impacts.

It could be argued that access restrictions in the MK could be imposed and effectively enforced on any new access in order to protect critical wildlife habitats. However, there remains a relatively wide spread concern that the impact of non-compliant individuals represents a significant threat to wildlife productivity and diversity in the MK. This view is predicated on anecdotal experience and perhaps a belief that the government's long-term commitment and ability to enforce compliance is inadequate to safeguard the resource at stake in this particular setting.

Where alternate low impact road access is not available, heliportable drilling operations provide a much greater opportunity to avoid long-term impacts to wildlife habitat and wildlife, particularly for lower success rate exploration drilling. However, there remains some potential that heliportable operations could result in significant short-term stress and displacement of wildlife (see Section 4.1). The potential for longer-term range abandonment could occur where frequent helicopter site visits are required to locations within critical wildlife habitat or which may require low level flying enroute to a given location. The species with greatest potential to be impacted in this regard are likely Stone's sheep and mountain goat due to their strong reaction to helicopters and low flying aircraft as well as grizzly bear when this species may seasonally seek more open terrain.

During load slinging and flying in general, conventional practice is to fly via the most direct route. Avoidance of critical wildlife habitat can mitigate these impacts, depending on the site, but may result in increased helicopter costs.

Figure 14 Habitat Suitability of Stone's Sheep

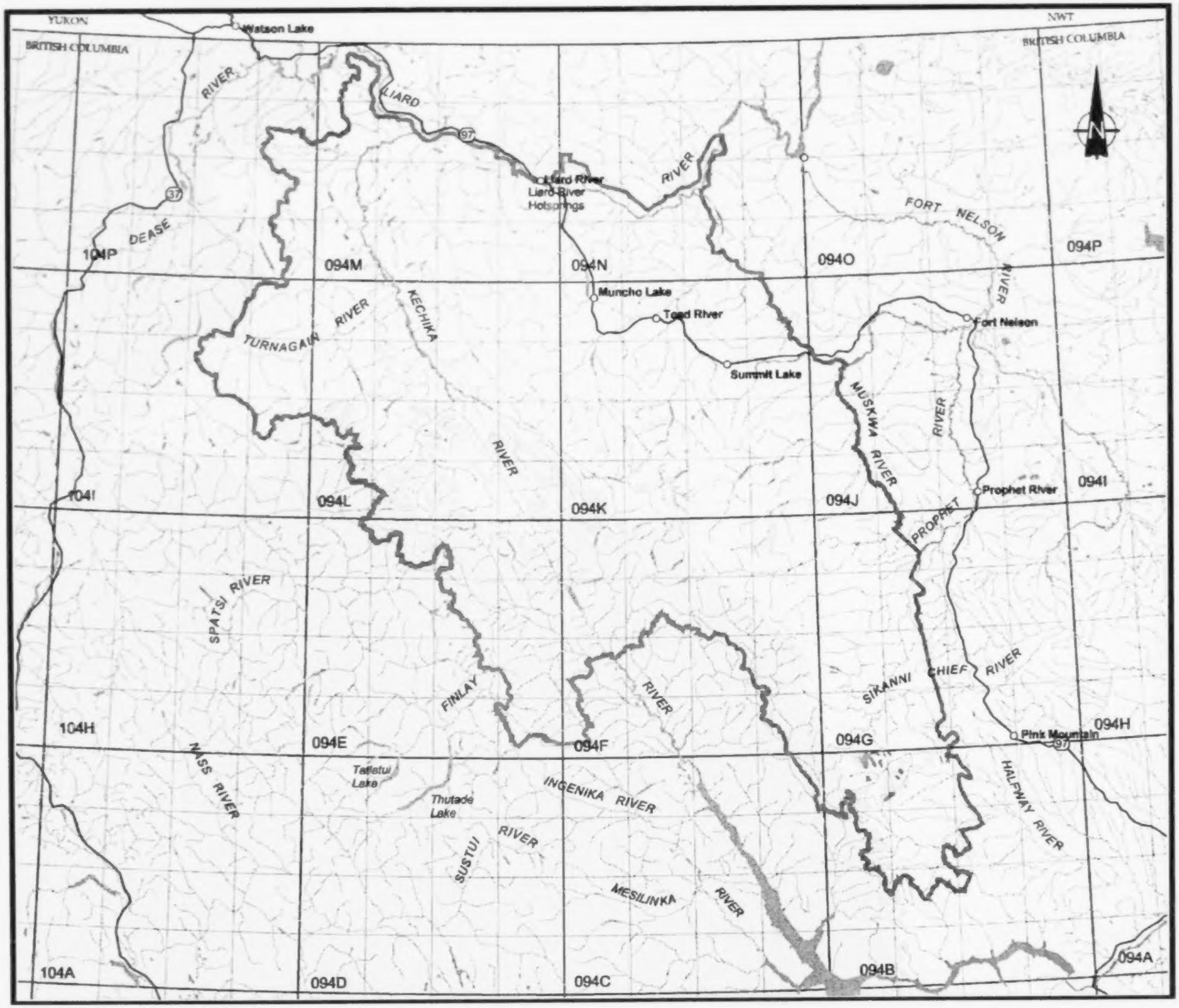

YUKON
BRITISH COLUMBIA
NWT
BRITISH COLUMBIA
Watson Lake
RIVER
DEASE
37
104P
LIARD
97
Liard River
Liard River
Hotsprings
RIVER
FORT NELSON RIVER
094M
094N
094O
094P
Muncho Lake
Toad River
Summit Lake
Fort Nelson
TURNAGAIN RIVER
KECHIKA
RIVER
MUSKWA RIVER
RIVER
PROPHET
Prophet River
104I
094L
094K
094J
094I
SPATSI RIVER
FINLAY
RIVER
SIKANNI CHIEF RIVER
104H
094E
094F
094G
094H
Pink Mountain
97
NASS RIVER
Tatlatui Lake
Thutade Lake
INGENIKA RIVER
HALFWAY RIVER
SUSTUT RIVER
MESILINKA RIVER
104A
094D
094C
094B
094A
N

FIGURE 14

HABITAT SUITABILITY FOR
STONE'S SHEEP

MUSKWA-KECHIKA MANAGEMENT AREA
HELIPORTABLE DRILLING STUDY

LEGEND

▬	Muskwa-Kechika Management Area Boundary
○	City
—	Major Road
	Major Watercourse
▨	Waterbody
☐	1:250,000 map sheet grid

Habitat Suitability Rating

■	Very High
	High
	Moderate
	Habitat Suitability Mapping Not Available

Sources:

Muskwa Kechika Management Area Boundary:
BC Ministry of Sustainable Resource Management 2000
Hydrology: © 2000. Government of Canada with
permission from Natural Resources Canada.
Habitat Suitability: BC Ministry of Environment, Lands and Parks 1999

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of this data are advised that errors in the data may be present.

SCALE: 1:1,750,000

20 0 20 40 60 Kilometres

(All Locations Approximate)

CALGARY ALBERTA

June 2002

2556

Figure 15 Habitat Suitability of Mountain Goat

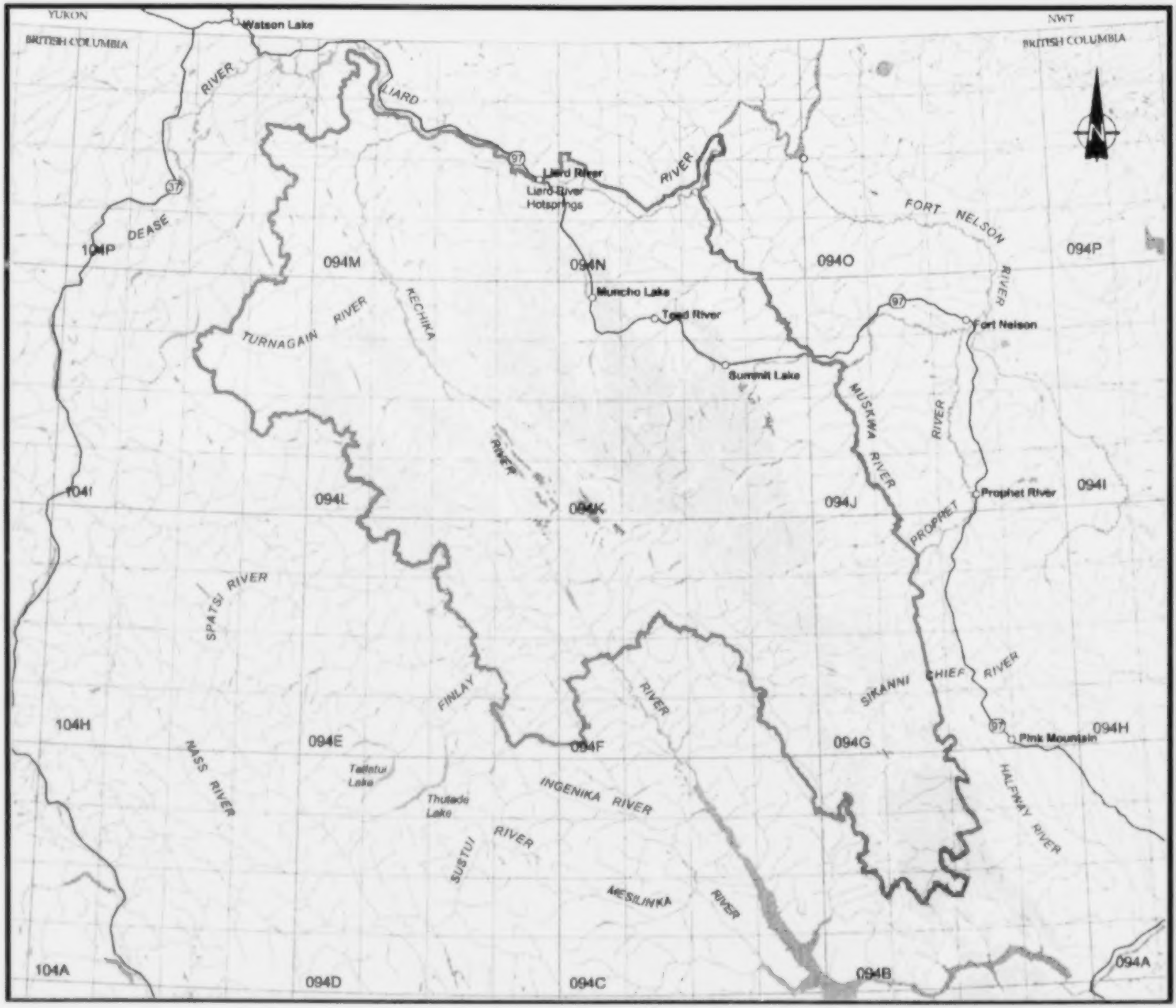

YUKON
BRITISH COLUMBIA
NWT
BRITISH COLUMBIA
Watson Lake
RIVER
LIARD
37
DEASE
104P
97
Liard River
Liard River Hotsprings
RIVER
FORT NELSON
RIVER
094M
094N
094O
094P
KECHIKA
TURNAGAIN
RIVER
Muncho Lake
Toad River
97
Fort Nelson
Summit Lake
MUSKWA RIVER
RIVER
RIVER
104I
094L
094K
094J
PROPHET
Prophet River
094I
SPATSI RIVER
FINLAY
RIVER
SIKANNI CHIEF RIVER
104H
094E
094F
094G
97
Pink Mountain
094H
NASS RIVER
Tatlatui Lake
Thutade Lake
INGENIKA RIVER
SUSTUT RIVER
MESILINKA RIVER
HALFWAY RIVER
104A
094D
094C
094B
094A

FIGURE 18

HABITAT SUITABILITY FOR
MOUNTAIN GOAT

MUSKWA-KECHIKA MANAGEMENT AREA
HELIPORTABLE DRILLING STUDY

LEGEND

▬ Muskwa-Kechika Management Area Boundary
○ City
— Major Road
Major Watercourse
▨ Waterbody
☐ 1:250,000 map sheet grid

Habitat Suitability Rating

▨ Very High
High
Moderate
Habitat Suitability Mapping
Not Available

Sources

Muskwa Kechika Management Area Boundary
BC Ministry of Sustainable Resource Management 2000
Hydrology: © 2000. Government of Canada with
permission from Natural Resources Canada
Habitat Suitability: BC Ministry of Environment, Lands and Parks 1999

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of this data are advised that errors in the data may be present.

SCALE: 1:1,750,000

(All Locations Approximate)

June 2002

2555

The characteristics and energy levels of sound associated with helicopters vary depending on the helicopter used, temperature and the setting. Larger helicopters tend to be louder; helicopters with multiple rotors tend to be quieter than those with fewer; helicopter noise tends to carry farther under cold conditions; and noise can be amplified when flying close to rock walls or in alpine basins.

The longer-term impact of road development on critical wildlife habitats still likely outweighs the impact associated with shorter-term heliportable drilling and operations.

2.8 Land Use

Land use within the MK includes horseback riding, ATV-based recreation, motorized and non-motorized boating, recreational and subsistence hunting and fishing, trapping, commercial guide outfitting, commercial trail riding, oil and gas exploration and development and forestry.

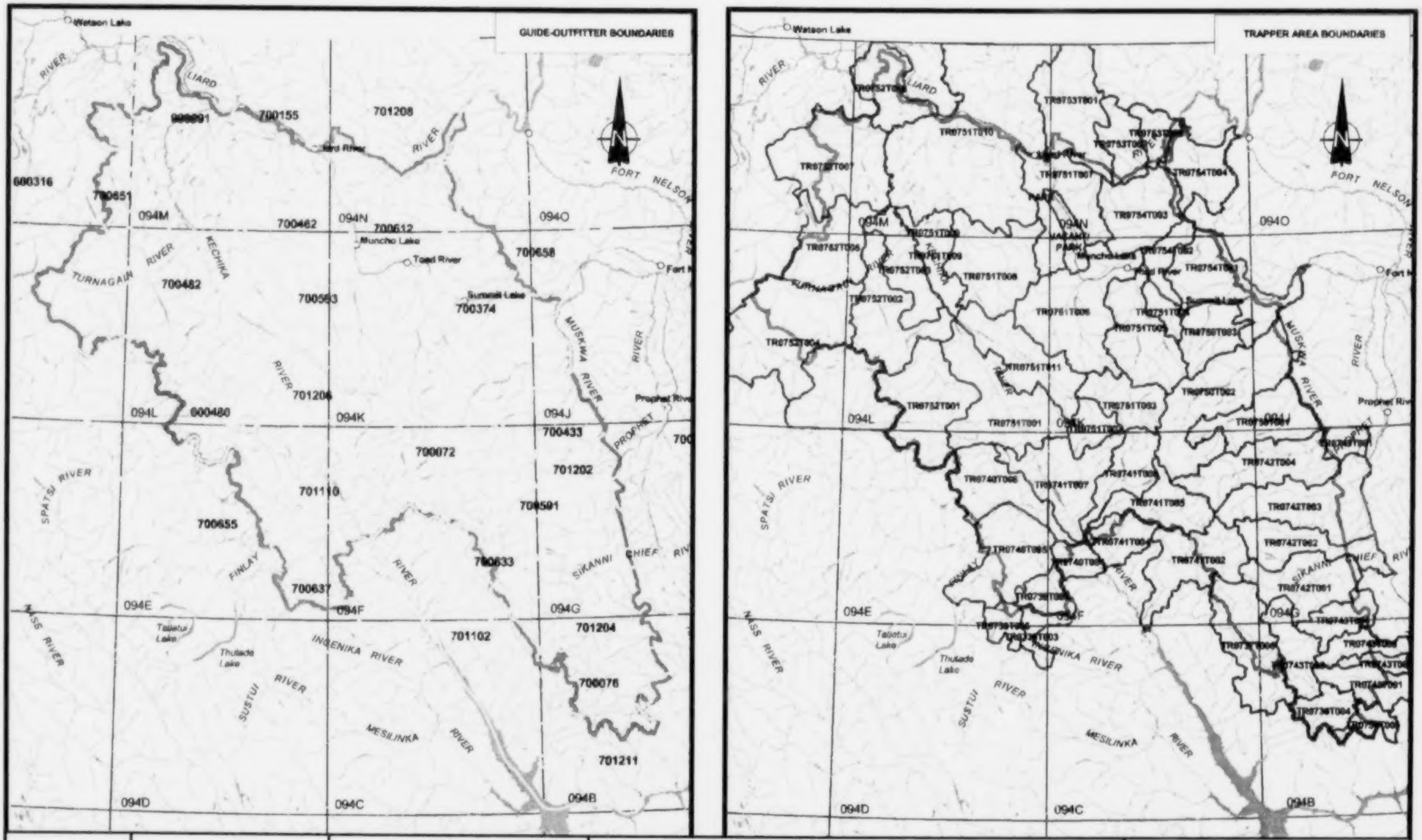
Use and creation of conventional road access in this land use setting can, if sensitively planned, for some interests and individuals, create a desired and improved resource access alternative. For others, road development is believed to lead to a significant degradation of the environment and associated opportunities (*e.g.*, guide outfitting, trapping). Heliportable drilling has potential to alleviate some of these latter concerns, but the associated noise and activity can impair recreational experiences. To some extent, these helicopter impacts can be avoided through planning flight patterns and seasonal and daily timing restrictions, keeping in mind however, the desirability of maximizing daylight flying hours.

2.8.1 Guide Outfitting and Trapping

There are 28 guide outfitting areas in the MK (Figure 16). The industry focuses on hunting opportunities for Stone's sheep, elk, moose, mountain goat, caribou, grizzly bear and black bear. The activity attracts international sport hunters to northeastern BC and generates about $50 million USD to $60 million USD in economic activity in BC annually (Guide Outfitters Association of BC 2002). The highest value hunts are for Stone's sheep (*e.g.*, $17,500 - $21,000/hunt). These hunts occur from early August to mid-October (BC Ministry of Water Land and Air Protection 2001).

There are approximately 56 trapping areas within the MK (Figure 16). Species trapped include wolverine, marten and fisher.

Figure 16 Guide Outfitting and Trapping Boundaries


GUIDE-OUTFITTER BOUNDARIES
TRAPPER AREA BOUNDARIES
Watson Lake
LIARD
RIVER
FORT NELSON
Muncho Lake
Toad River
Summit Lake
Fort N
Prophet River
PROPHET
MUSKWA RIVER
KECHIKA
TURNAGAIN
RIVER
SPATSI RIVER
FINLAY
SIKANNI CHIEF RIVER
INGENIKA RIVER
NASS RIVER
SUSTUT RIVER
MESILINKA RIVER
Tatlatui Lake
Thutade Lake
094M
094N
094O
094L
094K
094J
094E
094F
094G
094D
094C
094B
600316
700651
600891
700155
701208
700462
700612
700658
700482
700563
700374
701206
600480
700433
700072
701202
701110
700591
700655
700633
700637
701204
701102
700076
701211

SCALE 1:2,000,000

(All Locations Approximate)

June 2002

2555

Sources
Muskwa Kechika Management Area Boundary
BC Ministry of Sustainable Resource Management 2000
Hydrology © 2000 Government of Canada with
permission from Natural Resources Canada
Trapper/Guide-Outfitter Boundaries: Ministry of Water,
Land and Air Protection, Wildlife Branch 2001

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of this data are advised that errors in the data may be present.

LEGEND

―	Muskwa-Kechika Management Area Boundary	○	City		Major Watercourse
▭	Trapper Areas	―	Major Road	▨	Waterbody
	Guide-Outfitter Areas			▭	1:250,000 map sheet grid

FIGURE 16

GUIDE OUTFITTING AND TRAPPING BOUNDARIES

MUSKWA-KECHIKA MANAGEMENT AREA
HELIPORTABLE DRILLING STUDY

Significance

Guide outfitting success depends largely on the ability of guide outfitters to provide a high quality wilderness experience and a reasonably good chance for the client to obtain a trophy animal. Road construction for oil and gas exploration and development results in relatively long-term alteration of the landscape aesthetic and solitude, and has the potential to result in generally increased human use for motorized and equestrian access. This increased access has the potential to increase industrial and recreational noise levels, as well as increase wildlife displacement and mortality. While guide outfitters may benefit by some limited access development, the overall effect of conventional road construction degrades the wildland experience and reduces their ability to compete in the market place. Secondary support services such as airlines, hotels and other local businesses may also be affected. Confining oil and gas activity to the winter period in general, reduces overall impacts to guide outfitting though still results in some long-term adverse impacts, particularly where roads result in the creation of long-term unregulated access and degradation of the visual landscape.

Heliportable drilling avoids most of the long-term physical impacts of road development such as landscape modification and increased conventional access. These impacts are traded off with increased wide spread noise impacts and increased potential for displacement of sensitive high valued wildlife species in the MK such as Stone's sheep. Such impacts may be short-term where a well is unsuccessful, however, in the production scenario, helicopter noise impacts on the wilderness experience and wildlife would be extended through a longer period (*e.g.*, many years).

Adjustments to flying routes, scheduling of flights and specifying the type of helicopter may offset some of these impacts. Such adjustments may or may not add additional flying time and costs to heliportable operations. Adjustments to seasonal flying opportunities would have to be reconciled with interests in maximizing the daylight hour flying opportunities.

Conventional winter and all-weather road construction has been suggested to interfere with trapping activities by obstructing trapper movement (*e.g.*, as a result of snow berms and road cuts), as well as indirectly through adversely affecting furbearer habitat and movement patterns. Heliportable drilling would avoid such impacts.

2.8.2 Backcountry Recreation

The MK is among the most significant backcountry recreation areas in BC. The area attracts substantial resident use for hunting, fishing and general wilderness recreation. Most of this use occurs in the summer and fall. The area is currently accessed by recreationists using horse, ATV, jet boat and to a lesser extent on foot. Commercial backcountry recreation allows commercial businesses to obtain tenure in the backcountry to run nature-based wilderness tourism opportunities. At the present time, tenures are being reviewed and are not currently being issued for areas within the MK (BC Parks 2000). To a limited extent, this activity is currently being undertaken by the guide outfitters in the MK.

Significance

Conventional road based oil and gas development is typically viewed as incompatible with retention of wilderness recreation values, particularly where such development becomes extensive, results in profound landscape alteration and overlaps with periods of intensive recreational activity. Development of unrestricted conventional road access provides potential opportunity for physically, improved access for equestrian users and clearly improves accessibility by motorized vehicle users. In the absence of effective management policies, this can in turn put motorized vehicle users in conflict with horse or foot-based recreationist including commercial backcountry operators not using motorized access. A helicopter based exploration program avoids the physical impacts of conventional road access and to some extent can be seen to replace the physical impacts with more intense acoustic impacts.

Studies in other jurisdictions, to some extent, have confirmed that aircraft use is incompatible with the public's perception of the proper management and use of protected areas. A 1998 survey of public opinion by the National Parks Conservation Association in the United States revealed that 87% of the respondents felt that aircraft overflights in National Parks should be limited or banned. Similar concerns were also raised for other forms of motorized recreation (National Parks Conservation Association 2000).

2.8.3 Forestry

Commercial forestry is allowed in non-protected areas in the MK, but is subject to various planning requirements depending on the zone in which it occurs. Most forestry to date has been concentrated in the Graham River watershed along the southern boundary of the MK.

Significance

Conventional oil and gas access road development within areas also targeted for timber harvest affords some opportunity to subsidize road building costs for forest operators and conversely road development by the forest industry provides some opportunity to subsidize or defray road building costs associated with oil and gas activity. In some cases, oil and gas access roads have advanced timber harvest schedules where the two activities overlap and would be avoided in cases where heliportable drilling occurs.

2.8.4 Mining

Mining is permitted in portions of the MK, however, to date no mine developments have been proposed. The MK does include what are believed to be potentially significant mineral resources that may be pursued depending on exploration results, the regulatory environment, market strength and investor confidence.

Significance

The economics of most mineral finds typically requires development of surface access or rail transport. In relatively few cases the ore grade is of high enough value that air transport is economic. To the extent that any extensive mine access is developed, it may alter the practicality of heliportable drilling proximate to such sites.

3.0 IMPACTS OF ROADS

Road developments within the MK have the potential to directly and indirectly affect fish and wildlife populations, their habitats as well as the wilderness landscape aesthetic through the following means:

- physical habitat removal and alteration;
- displacement of species from productive habitat as a result of a human avoidance response or barrier effects;
- increased species vulnerability to mortality from fishing, hunting and vehicle collision;
- increased species vulnerability to predation;
- high visibility landscape alteration; and
- increased visitation and concentrations by various forms of recreational user.

A review of the impacts of roads and backcountry recreation on wildlife, fish, plant and wildlife habitat values was previously commissioned under the Muskwa-Kechika Trust Fund (Higgins 2001). The following subsections provide a synthesis of the results of that review, along with information obtained from other reviews, research and observation.

3.1 Impacts on Fish and Aquatic Ecosystems

Road construction within the MK can affect fish and aquatic ecosystems by increasing erosion and sedimentation/siltation; disturbance and removal of riparian vegetation; increasing fish mortality resulting from increased recreational access to fish populations (this may be viewed as a net positive recreational benefit by some); and increased potential for spills or leaks of environmental contaminants affecting either surface or groundwater.

Studies have demonstrated that construction of roads and other linear disturbances (*e.g.*, pipelines) can increase sediment yield by 22% to 400% (Antoniuk 1994; Furniss *et al.* 1991, Rothwell 1979, Martz and Campbell 1980). Fish physiology and behavior can be affected by both an increase in turbidity and suspended solids associated with silty run-off from roads and other disturbances. Research has shown that juvenile salmonids reared in artificial test channels with high turbidity levels grew less than those reared in clear water (Sigler *et al.* 1984), and that gills showed structural damage at sub-lethal concentrations of suspended sediments (Cederholm and Salo 1979). Higher stream crossing densities in Idaho have been shown to coincide with reduced fish occupation when compared with similar but unroaded drainages (Huntington 1998). Increased access can lead to increased angling pressure on sport fish and has for example, been the primary cause believed to have led to over-harvest of Arctic grayling in northern Alberta (Stelfox and Wynes 1999).

Within the MK in general, the management regime has strived to promote or require development of lower impact winter exploration roads where possible rather than multi-season all weather roads. Low impact winter roads typically have significantly less potential to impact aquatic resources due to the reduced surface disturbance, tendency for many streams to have significantly reduced to negligible surface flows, reduced requirements for access control, and opportunities this season may provide for construction of low impact ice roads and crossings (Plates 3 and 4 in Section 2.3.3).

3.2 Impacts on Wildlife

The ecological effects of roads and functionally similar linear corridors (*e.g.,* some pipelines and seismic lines) on wildlife are associated with direct habitat removal or alteration and a range of indirect affects related to animal behavior and human access. Indirect impacts occur when species are displaced by human activity in proximity to roads or activities otherwise facilitated by roads, or where wildlife is exposed to increased vulnerability to regulated and non-regulated hunting. While individuals of some species may avoid roads, there are others which use them as movement corridors which can increase their vulnerability to hunting mortality as well as potentially alter predator prey dynamics. Roads also increase potential for animal-vehicle collisions and alter ecological relationships with other species (*e.g.,* predator-prey encounters, reduced habitat separation/increased competition for forage). Brief summaries of the response and probable consequence of road development on a select group of species occurring within the MK are presented in the subsections that follow.

3.2.1 Moose

Moose show a relatively high tolerance of non-threatening human activity (Coady 1982) including helicopter supported seismic programs (Bangs and Bailey 1982), however, there are examples in other studies which have suggested some avoidance reactions of moose to human activity, including road construction (Jalkotzy *et al.* 1997). Within the boreal forest, wolf movement appears to be enhanced by the creation of linear disturbances and has been suggested to have a bearing on woodland caribou habitat use and susceptibility to predation (James and Stuart-Smith 2000). These same road/corridor predator relationships may hold for moose. To the extent this is true, development of additional road networks within the MK will presumably increase the exposure of moose and other ungulates to wolf predation, as well as increase potential vulnerability to legal and illegal hunting mortality where access is inadequately managed.

3.2.2 Elk

Elk behavior, habitat use and mortality has been shown to be affected by roads in various ways. For example, in a study based on counts of fecal pellet group density, Rost and Bailey (1979) observed that during winter, elk and mule deer in Colorado appeared to decrease in close proximity to roads. In a controlled study of female Roosevelt elk in Oregon, it was observed that female elk in areas with open road access had increased their daily movements, core area size and home range and therefore energy needs relative to disturbance due to vehicular access on roads was limited gate closures (Cole *et al.* 1997). In a study of radio collared bull elk in Idaho, mortality rates were significantly higher in heavily roaded areas than in areas with few roads, while areas with managed access exhibited intermediate mortality rates that were not significantly different from either access extreme (Leptich and Zager 1991). In a study of cow elk in Montana, Edge and Marcum (1991) found that the probability of elk use in areas proximate to roads was significantly lower where there were long site lines relative to roads and that high traffic volumes reduced the probability of elk use. These patterns occurred in all seasons. A recent report by the Rocky Mountain Elk Foundation on intensive, experimental studies of elk in Oregon indicated elk may be displaced in excess of a mile from roads and again that response appeared related to intensity of road use (Stouder 2002). At the same time, the phenomenon of elk and other wildlife habituating to roads and associated human activity in park settings is well known. In these settings, displacement effects may at times be traded off with increased frequency of animal vehicle collisions. Within the MK, it can be expected that road access will adversely affect elk and other wildlife and that the magnitude of this effect will be largely dependent on the extent to which levels of road use are controlled and the proximity of roads to critical habitats and corridors.

3.2.3 Caribou

Recent research on woodland caribou in northern Alberta has shown that caribou may be adversely affected by the creation of linear corridors (Dyer 1999, Oberg 2001, James and Stuart-Smith 2000). It should be noted that studies on foothills inhabiting caribou showed that caribou avoided active roads to a maximum distance of 500 m and inactive roads to a maximum distance of 250 m (Oberg 2001). Oberg (2001) did not detect significant avoidance of seismic lines by caribou, but did note that caribou were 26% more likely to be observed around seismic lines that were more than 23 years old than around more recent seismic lines.

Anecdotal observation of woodland caribou in the MK, as well as along the Alaska Highway suggests that at least some percentage of caribou will, at certain times show considerable tolerance to vehicular traffic associated with public transportation corridors and restricted use industrial roads (Plate 5)

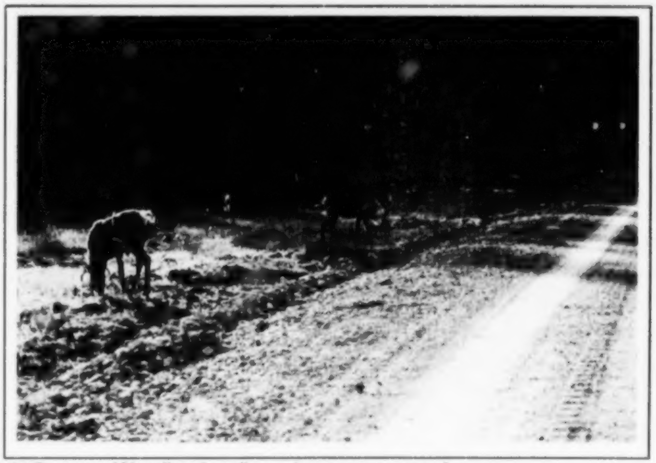


Plate 5 Woodland caribou along access road

3.2.4 Mountain Sheep and Goats

Mountain sheep appear relatively tolerant of roads and non-threatening activity associated with them (Jalkotzy *et al.* 1997). Bighorn sheep in both hunted and un-hunted populations have been observed crossing busy highways, feeding by road sides and occupying areas in close proximity to industrial disturbance. The primary effect of roads on Stone's sheep in the MK can be expected to relate to somewhat increased vulnerability to hunting, as well as to direct habitat loss where roads are constructed deeply into traditional sheep range.

In a recent review of the effects of linear disturbances on wildlife, Jalkotzy *et al.* (1997) reported that the effects of linear disturbances on mountain goat were not well documented compared to many other large mammal species. This may in part be due to the fact that road building is highly unsuitable in areas typically frequented by mountain goat (Plate 6). From the studies reviewed by Jalkotzy *et al.* (1997), it is apparent that goat response is variable but can include temporary or longer-term range abandonment, seemingly rapid habituation and change in diurnal behavior (*e.g.*, reduced day time use of some areas), crossing two lane highways to reach mineral licks and increased vulnerability to hunting mortality.

Plate 6 View of mountain goats on steep south-facing slope.

3.2.5 Grizzly Bear

A number of studies have examined the relationship between roads and grizzly bears including Mueller (2001), Benn (1998), Mace *et al.* (1999, 1996), Kasworm and Manley (1991,1998), McLellan and Shackleton (1988) and Mattson (1993). These studies have in general determined that roads and trails subject to human use result in altered patterns of grizzly bear habitat use and/or increased risk of mortality which have potentially adverse consequences for grizzly bear populations. Among the findings of this research, Mattson *et al.* (1987) observed that bears avoided habitat within 3 km of developments, 2 km of roads in summer and 4 km of roads in fall. McLellan and Shackleton (1988) observed that bears used habitat within 100 m of roads less than expected. Kasworm and Manley (1991, 1998) observed apparent displacement effects ranging from 914 m from an open road to 122 m from a trail and in subsequent studies observed that areas within 500 m from a road received significantly less use by grizzly bears, while areas greater than 1000 m received significantly greater use. Mueller (2001) observed a seeming age related difference between tolerance for roads, with sub-adults showing greater tolerance than adults during times of increased human activity. Level of road use appears to be an important determinant in the response and affect of roads on grizzly bear and other species. In unhunted populations, grizzly bear, like many other species, can habituate to access corridors and some levels of human activity.

3.2.6 Birds

Cumulative indirect loss of birds and bird habitat can also occur as a result of nest parasitism and predation facilitated by creation of forest edges and openings along roads and other linear corridors (Bunnell *et al.* 1998, King *et al.* 1998, Paton 1994). In a review of literature on habitat fragmentation effects, Albrecht *et al.* (1999) identify studies which suggest these effects are more pronounced in agricultural settings and in association with abrupt, man-made edges as opposed to more gradual edges associated with normal vegetation mosaics. Species most directly affected by this type of change are neotropical migrants as well as species such as northern goshawk and pygmy owl. Research on the distance within which edge effects occur suggests the effect may range from 10 m to 600 m (Albrecht *et al.* 1999).

3.2.7 Road Management Policy in the MK and Wildlife

In addition to formally establishing specific public access criteria on existing access corridors within the MK, the areas management regime has also strived to promote or require development of lower impact winter exploration roads where possible rather than multi-season all-weather roads. Low impact winter roads, if properly sited, built and managed, have significantly less potential to impact wildlife due to their reduced suitability for conventional human access. However, they still leave open potential for the "predator corridor" phenomenon reported in some research (James and Stuart-Smith 2000) as well as provide for some altered species movement patterns. These latter effects have some potential to be reduced or avoided where woody rollback and more aggressive reforestation are used.

4.0 IMPACTS OF HELICOPTERS

The impact of air traffic, in particular helicopters, on wildlife, recreational land use, and wilderness landscape aesthetic has been the focus of a wide range of research projects and public debates. These concerns have arisen around proposals for heli-tourism, heli-skiing, wildlife surveys using helicopters and industrial developments requiring the use of helicopters.

4.1 Impacts on Wildlife

A contemporary review of research findings in regard to helicopter impacts on large mammals which occur in the MK or which may be extrapolated to species which occur in the MK is summarized in Table 5. This research suggests that mountain sheep and goats are likely more sensitive to helicopters compared with other species. This reaction is likely attributable in part to the interaction between avian predators and these two species, and perhaps reaction to loud noise associated with avalanches.

In the context of the present study, a local helicopter pilot with over 10 years experience flying in the southern MK and nearby areas was invited to comment on his observations of wildlife response to helicopters. From this pilot's experience the most sensitive species were mountain sheep, goats, bison and wolves (Adamson, pers. comm.). Wolverines are noted to be relatively tolerant of helicopters. The pilot noted that flyovers in the 300 m above ground level (agl) range result in relatively little response, but that changes in flight path and circling will illicit more of a response. These maneuvers tend to alter the noise of the helicopter and combined with the change in flight path cause the helicopter to be perceived as a much more potential threat relative to an immediately transient stimulus.

Research and anecdotal observation suggests that wildlife response to helicopters overall varies depending on the species, the habitat in which it occurs, proximity to cover or escape terrain, season, flight pattern and distance, as well as disturbance history. In this latter regard, species which have been subject to capture or harassment by helicopter for wildlife studies or other purposes can be expected to react more strongly than populations which have not been. Helicopter activity can be a substantive impact on large animals in open habitats. The level of impact appears dependent on how close and loud the aircraft activity is. Aircraft activity that intentionally focus on or repeatedly chase wildlife or disturb a certain area, can have a strong negative effect on wildlife. Habituation to non-threatening overflights appears likely, particularly where low level high frequency traffic is avoided. To some degree, these same observations also apply to roads. Planning of flight paths and approaches can confine the impacts to the actual area of the oil and gas activity. Following the cessation of aircraft flights, wildlife may cease to be impacted by helicopter access. In a similar way, the impacts of roads may subside with reduced levels of human activity, however, in the case of roads, predator corridor effects as well as hunter access effects on wildlife persist as long as the road remains.

TABLE 5

SUMMARY OF RESEARCH ON THE IMPACTS OF HELICOPTER AND AIRCRAFT ON LARGE MAMMALS

Species	Aircraft	Location	Observation	Reference
Dall's Sheep	Helicopter	Yukon	Observed that sheep responded sooner to helicopters the more distant they were from suitable escape terrain or concealing terrain. Response was strongest when sheep were on steep rocky terrain, were in small groups or where groups had large proportions of lambs.	Frid (1998) as cited by Paquet and Demarchi (1999)
Bighorn Sheep	Helicopter	Alberta	Recorded elevated heart rates in sheep. Multiple overpasses resulted in heart rates that were elevated for long periods (up to two hours). Response appeared to vary significantly with habitat (greater when sheep are away from escape terrain). Some habituation reported.	Stemp (1983)
Bighorn Sheep	Helicopter	Alberta	Sheep abandoned an area of winter range during a period of heavy helicopter activity in November and returned a month alter after activity had ceased.	Morgantini (1993)
Bighorn Sheep	Unspecified	Alberta?	Demonstrated that low flying aircraft at =>400 m did not elicit a heart rate response in ewes.	MacArthur *et al.* (1979, 1982)
Bighorn Sheep	Helicopter	Alberta	Rarely allowed helicopter to approach closer than 800 m before running.	Horesji (1975) as cited by Shank (1979)
Bighorn Sheep (*Ovis Canadensis nelsoni*)	Helicopter	Arizona	Observed that bighorn sheep were sensitive to disturbance in winter (43% reduction in feed intake) but not during spring. Identified a disturbance threshold of 250 m to 450 m.	Stockwell *et al.* (1991)
Desert Bighorn Sheep (*Ovis canadensis mexicana*)	Cessna 172 and 182	Western Arizona	Sex and age classes had similar reactions. Sheep in this area appeared accustomed to aircraft flying >100 m above ground level (agl), flights at <50 m agl caused sheep to leave the area.	Krausman and Hervert (1983)
Desert Bighorn Sheep	Bell 206 B III	California	Adult males and females moved about 2.5 times farther the day following a helicopter survey than the day prior to the survey. Proximity of escape terrain did not affect the strength of response. Reported that even a low intensity survey resulted in "major changes in mountain sheep distribution" and that "mountain sheep reacted severely to our helicopter surveys".	Bleich *et al.* (1990)
Mountain Goat	Helicopter (Bell 206B Turbo and Bell 212)	Alberta	Studied 109 marked mountain goats. Mountain goats were disturbed by 58% of flights and were more adversely affected when helicopters flew within 500 m. 85% of flights within 500 m caused goats to move >100 m, 9% caused them to move >1,500 m. Observed some breakup of social groups and one severe injury. Recommended restriction of helicopter flights within 2 km of alpine areas and cliffs that support mountain goats.	Cote (1996)
Moose	Aircraft	Unspecified	Moose are considered a northern ungulate least affected by aircraft disturbance though research lacking. Reported to be less reactive than caribou. More than half of moose flown at =< 60m reacted strongly. Other data referenced suggested 13% of moose reacted strongly when aircraft =< 60m.	Shank (1979) citing numerous studies.
Elk	Helicopter	Alberta	Bull elk showed little reaction to helicopter whereas cows and calves showed a greater flight distance. Flight distance was greater when they were in the open.	Horesji (1975) as cited by Shank (1979)

TABLE 5 Cont'd

Species	Aircraft	Location	Observation	Reference
Elk	Helicopter	Muskwa-Kechika, Southern Alberta	Elk show tolerance to helicopter fly-overs and one time circling above approximately 500 m. Continuous circling invariably results in flight to cover. Response inversely proportionate to distance.	Glaholt pers. comm.
Bison	Helicopter	Muskwa-Kechika	Bison show some tolerance to be displaced by single fly-overs and some circling above approximately 500 m. Response inversely proportionate to distance.	Glaholt pers. comm.
Woodland Caribou	Helicopter	Alberta	Caribou approached the helicopter after it landed	Horesji (1975) as cited by Shank (1979)
Woodland Caribou	Helicopter	Muskwa-Kechika and Pine Pass Area	Appear relatively tolerant of single higher elevation fly-overs and some higher altitude circling (>500 m). Appear more sensitive during early post calving and less sensitive during fall and winter. Observed bull caribou cross and feed within 100 m of helicopter following landing.	Glaholt pers. comm.
Barren Ground Caribou	Aircraft	Northwest Territories, Yukon and Alaska	Highly variable response. Response seems to vary with season. Winter is quite commonly reported as season of greatest sensitivity followed by calving period.	Shank (1979) citing numerous studies.
Barren Ground Caribou	Bell 206 B Turbo	Northwest Territories	A greater percentage of caribou were walking, trotting or galloping during post-helicopter disturbance than pre-helicopter disturbance. The rates of nursing were slightly higher during pre-disturbance than post disturbance and were lowest during the disturbance.	Gunn *et al* (1982)
Peary Caribou	Bell 206 B Turbo	Northwest Territories	Reported that group size and type, number of calves in the group, sun position and wind direction relative to the helicopter and animals, previous activity of the animals and terrain all contributed to the level of response exhibited by the animals. Observed an inverse relationship between response level and helicopter altitude or distance away.	Miller and Gunn (1979)
Mule Deer	Helicopter	Alberta	Reported to be more sensitive than elk.	Horesji (1975) as cited by Shank (1979)
Grizzly Bear	Helicopter	SE British Columbia, Montana	Strongest response when bears in open. Flight direction relative to bear appeared important. In forested habitat high intensity activity is required to elicit response. Most grizzly bears in forested habitats stayed around for hours or days after helicopter activity and those that did move, did so slowly.	McLellan and Shackleton (1989)
Grizzly Bear	Helicopters and Fixed wing	Various North America	58% of bears responded strongly to fixed wing, while 71% responded strongly to helicopter. Bears may run from aircraft 0.4 to 0.9 km distant at 1000 m agl. Others suggest altitude has little effect. Feeding bears show little fear. Bears have been suggested to be more sensitive than moose or caribou. Reaction to aircraft believed more severe where there is no cover. Previous experience with aircraft plays very important role in bear reaction (greater response by bears that were captured using aircraft).	Shank (1979) citing numerous studies.
Grizzly Bear	Helicopters and Fixed wing		Reported that grizzly bear may be more sensitive to helicopter than to fixed wing aircraft. A study found that 90% of grizzlies reacted strongly to helicopters and 21% reacted strongly to fixed wing aircraft.	The Interagency Grizzly Bear Committee (1997)
Wolves	Helicopter	Muskwa-Kechika	Intolerant of circling below about 500 m	Glaholt pers. comm.

TABLE 5 Cont'd

Species	Aircraft	Location	Observation	Reference
Wolves	Aircraft	Various North America	Reaction is highly dependent on past experience with aircraft. Wolves habituate quickly when they are not hunted from the air.	Shank (1979) citing numerous references
Bald Eagle	Helicopter	Arizona, Michigan	Bald eagles responded more to helicopters than fixed wing.	Grubb and Bowerman (1997)
Bald Eagle	Aircraft	Arizona	Response varied inversely with distance from aircraft. Aircraft were less disturbing than pedestrians, boats or gunshot.	Grubb and King (1991)
Golden Eagle	Jet Ranger	Montana, Wyoming	Nesting golden eagles remained on nest when helicopter was within 100 m. Ferruginous hawks left nest when helicopter was closer than about 500 m.	Glaholt pers. comm.
Wildlife (general)	Aircraft	Unspecified	Helicopter overflights are more stressful than fixed wing. Frequent predictable overflights are more likely to lead to habituation.	National Park Service (1994).
Wildlife (general)	Aircraft	northeastern BC	Aircraft impacts are a function of how close and loud the aircraft is, and becomes a serious issue when frequency of disturbance is high.	Harper and Eastman (2000)

4.2 Helicopter Flight Guidelines

In Alberta and BC, guidelines have been developed for managing helicopter impacts. In Alberta, a 2,000 m buffer between mountain goats and intensive helicopter activity (heliportable seismic) is recommended. Industrial activity within an identified goat/sheep land use zone can only occur between July 1 and August 22 to avoid spring lambing/kidding season and should be at least 400 m agl, except where specifically authorized (Alberta Sustainable Resource Development 2001).

Within the MK, flight guidelines are presented in the Besa Prophet Pre-tenure Plan to minimize harassment to wildlife. A coordinated flight plan is required and must identify the number of flights, staging areas, and altitudinal, temporal and spatial flight parameters. The guidelines are listed in Table 6.

TABLE 6

FLIGHT GUIDELINES IN THE BESA PROPHET MANAGEMENT AREA

Species	Guidelines
Stone's sheep	Limit helicopter and fixed-wing flight altitudes to a minimum of 500 m over designated sheep habitats and a minimum of 1,000 m horizontal distance from designated sheep habitats. For sensitive sites (*e.g.*, natal areas) maintain a 2,000 m horizontal separation from helicopter and fixed-wing flights. Distance interval restrictions may be relaxed for safety circumstances. Select heli-ports, pads and heli-spots for all helicopter activities to avoid locations within 2,000 m of designated sheep habitat.
Caribou	Limit helicopter and fixed-wing flight altitudes to a minimum of 500 m over designated caribou habitats; where there is a direct overlap of intensive helicopter over caribou habitats then considerations should be given to horizontal no-fly zones over critical habitat areas. Schedule helicopter and fixed-wing flights to avoid designated calving and later winter habitats. In cooperation with WLAP staff, select particular routes, heli-ports, heli-pads and heli-spots for all helicopter activities in the vicinity of caribou habitats.
Mountain goat	Maintain seasonal no-fly zones for helicopters and fixed-wing aircraft that are a minimum 2,000 m horizontal and vertical distance from designated goat habitats unless goats are separated by a physical barrier that would minimize disturbance levels (*e.g.*, mountain or terrain block). Distance interval restrictions may be relaxed by ameliorating circumstances such as safety concerns. Select heli-ports, heli-pads and heli-spots for all helicopter activities to avoid locations within 2,000 m of designated mountain goat habitats. Avoid helicopter and fixed wing disturbance of identified kidding areas from May 1 to July 15. Consider testing of NOTAR type helicopters to determine if their quieter operations have any effect of goat responses.
Grizzly bear	Limit helicopter and fixed-wing flight altitudes to a minimum of 300 m over designated grizzly bear habitats.

Source: BC Ministry of Sustainable Resource Management 2002b

4.3 Impacts on Land Use

The existing network of access roads and linear disturbances within the MK has a bearing on the feasibility and benefits derived from heliportable versus conventional drilling programs. Where a potential location can be developed immediately adjacent to an existing access corridor, there may be marginal environmental benefits to a heliportable program (particularly relative to incremental costs). However, this would be contingent on a thoughtful evaluation of the required upgrades for conventional access, increasing levels of traffic and their attendant impacts on the environment and land use. In some cases, such development may allow cost effective restoration or improvement of recreational access depending on the designated land use and how the project was planned. Allowing conventional access using an existing linear disturbance avoids some of the environmental impacts (*e.g.*, Stone sheep's disturbance, noise pollution) associated with heliportable drilling.

Heliportable drilling significantly reduces the conflict with backcountry recreational users concerned about the "look" of the land and who see road access as unacceptably and uncontrollably increasing the intensity and impact of human activity on the landscape. At the same time, heliportable drilling and subsequent heliportable servicing (unless road accessed) on productive wells can be seen to add significantly to what could be termed "noise pollution" within the wilderness settings of the MK. This impact may be of greater concern to commercial tourism operators and could be mitigated to some extent, if an oil and gas company could use existing access within the MK to minimize flight distances between a road accessible staging area and the heliportable well site by establishing least conflict flight paths and/or by commercial operators temporarily relocating their activities within their operating area. Heliportable impacts for a given well site would be primarily of short duration (one or two seasons).

It is unclear whether the public using the MK would in any particular area prefer to trade off potential road impacts with noise pollution, however the draft Besa Prophet Pre-tenure Plan indicates that stakeholders involved in the planning process have indicated a preference to maintain unroaded landscapes if possible (BC Ministry of Sustainable Resource Management 2002b). It needs to also be recognized that conventional drilling programs bring with them some amount of helicopter traffic though this would represent a fraction of that associated with a fully heliportable drilling program.

Heliportable operations would have relatively greater potential to interfere with Stone's sheep and mountain goats and any species specific sport hunting or eco-tourism where the flight path and load requires traverse at lower level flight over inhabited sheep and goat range. In most cases, a conventional access road follows lower elevation valleys as far as practical to achieve access to a drill site. This same approach, along with sensitive well site selection could be used for a heliportable operation although the acoustic effects could be expected to extend some distance from the actual flight path. Weather may also force abandonment of a given flight path and as such open the possibility of periodic conflict with guide outfitters and individuals engaged in trophy hunting or casual wildlife observation.

5.0 COMPARATIVE EVALUATION OF IMPACTS THROUGH THE LIFE CYCLE OF OIL AND GAS EXPLORATION AND DEVELOPMENT

The general significance and consequence of conventional road-based vs. helicopter-based oil and gas exploration and development on the various resources of value in the MK and existing land uses has been discussed in the previous sections. The consequence of these two options varies depending on the stage of development and the nature of any measures taken to reduce their impacts. These differences are discussed relative to the different phases of oil and gas exploration and development in the sections that follow.

5.1 Seismic Program

5.1.1 Conventional Seismic

Conventional seismic exploration has involved creation of linear disturbances by the use of bulldozers to cut typically 8 m wide clearings across a variety of terrain types. In some locations these disturbances have been extensive and resulted in many of the impacts associated with road construction. Due to their more rugged nature, lack of maintenance and bridge crossings, seismic lines, result in less overall vehicle access-related impacts to wildlife than a conventional all weather road in the same location. Conventional seismic may still have more chronic affects on aquatic habitats where chronic erosion problems have been created and ATV use prevents revegetation. Within the MK, conventional seismic lines constructed before 1994 are in many cases associated with the main access corridors into the area and have facilitated an increased level of human access and associated impacts in the area. Conventional cat-cleared seismic is no longer conducted in the MK due to the environmental impacts associated with it and also due to significant technical advancements, experience and cost efficiency in the area of heliportable seismic (Section 5.1.2).

The older cleared seismic lines are frequently the first consideration during route selection when planning oil and gas exploration roads or for follow-up corridors, however these old lines were often not planned to mitigate environmental impacts. These and the other trail systems within the MK may also provide a means of reducing some of the impacts, costs and risks of heliportable drilling where they were used to shorten the flying distance between a heliportable site and the nearest road accessible staging area. The desirability of this compromise would have to be weighed against the consequence of any road/trail upgrades required and the associated impact of activities on wildlife and recreation.

5.1.2 Heliportable Seismic

Considerable advancement and use in heliportable drilling technology has been associated with seismic exploration. Heli-seismic is undertaken where rugged and remote access is required and where there are considered to be particularly high environmental sensitivities. Heli-seismic is now standard through out the MK and Zones 1, 2 and 3 as identified in the BC Oil and Gas Handbook (1995). Heli-seismic is also used in Zone 4 for sensitive, inaccessible areas. Application of this technology to seismic programs has considerably reduced the conventional footprint of seismic programs from bladed 8 m wide lines to 2 m wide hand-cut avoidance lines. New GPS and heli-staking technology has reduced these hand-cut lines such that no sight lines are required and conspicuous disturbance is largely confined to periodic landing sites. Heli-seismic programs have the advantages of reduced costs for clearing and reduced impact to habitat and landscape aesthetics. Associated with this however, are aerial overflights and associated effects on wildlife and recreationists.

Impacts associated with heliportable seismic can be reduced to some degree by scheduling and adherence to flying guidelines, specifically planned to reduce impacts to wildlife and area users. Such planning is currently occurring in the MK. In summary, the long-term impact of heli-seismic operations compared with conventional seismic operations are significantly less in all areas of concern and are the standard for the MK.

5.2 Exploration Drilling

5.2.1 Conventional Exploration Drilling

Conventional road based exploration drilling results in a range of short-term and long-term impacts the magnitude of which are contingent on the location of the road, the standard to which it is built (all-weather, winter, snow/ice road, padded/matted road), season of use, the nature and commitment to access control and enforcement thereof, whether it is reclaimed immediately or kept open for subsequent drilling, pipelining operations or for other resource extractive industries (*e.g.*, forestry) or to serve a specific public access interest. Some locations within the MK lend themselves to development of low impact winter roads, whose impacts would be largely confined to the period and season in which the road is in actual use. Conventional road construction typically requires clearing and grading for the access road, as well as any borrow pits and log decks.

In the event of a blow-out involving large volume liquids release, there is likely to be a somewhat shorter response time with a conventional road-based exploration well than with heliportable, particularly where this contingency has not been adequately planned for.

At the present time, roads developed within the MK for exploration drilling must be reclaimed following well abandonment unless the road has been planned in conjunction with forestry interests, in which case the road may be maintained in a much more readily used form for a longer period. Considering the low success rate for most exploration drilling in the MK, and the lack of commercial forest stands in many valleys, it is clear that the service life of most of these roads is about one year. Roads to suspended wells may be required for several years pending decisions to re-enter or abandon these wells. The short essential life span of most exploration roads and requirements for reclamation within the MK would suggest that many of the access and erosion related impacts related to exploration road development could be mitigated within perhaps one to three years of the exploration activity. This is predicated on an assumption that these roads are not kept open for other purposes (*e.g.*, forestry, servicing a more remote conventional producing well). Impacts associated with altered landscape aesthetics, however, can be expected to endure for much more prolonged periods, particularly where exploration roads are pioneered through steep subalpine and alpine environments. Measures to reduce the creation of unnatural wildlife corridors associated with these linear features potentially would require more aggressive attention to restoration of contour and application of more substantial whole tree rollback.

5.2.2 Heliportable Exploration Drilling

Environmental impacts unique to heliportable exploration drilling are primarily associated with the need for high frequency and variable altitude helicopter traffic between a road accessible staging area and the well site and/or camp. These are estimated to involve the need for transport of 150 to 500 loads for rig, other heavy equipment and supplies in addition to potential daily flights over the estimated 90 to 120 day drilling programs anticipated in the area (Pare, Crowson pers. comm.). Based on discussions with companies engaged in active heliportable drilling in other areas, it appears that helicopter well sites can be expected to be perhaps 0.5 ha larger than conventional well sites in the MK. Somewhat greater localized terrain impacts can also be anticipated on heliportable drills due to the practice of typically locating the camp either immediately adjacent to the well site or up to 2 km away from the well site and connected by a trail or road. Arguably these terrain impacts would still in most instances result in considerably less direct impacts than for conventional road accessed well construction.

As discussed in 5.2.1 above it is likely that some what greater response time or reduced efficiency in regard to uncontrolled release of liquids may be associated with blow outs at heliportable well sites.

Based on this review, it appears that sheep and mountain goat would be likely the most sensitive receptors to helicopter displacement associated with heliportable drilling. The suggestion that grizzly bear are relatively reactive when in the open suggests some basis for concern for repeated flying at low elevation in certain open habitats more seasonally preferred by bears. It can be expected that low elevation flying most often during approaches and take-offs. It is likely that most other ungulate species also react more strongly to helicopters where they are more distant from cover and that flight paths that follow forested corridors are perhaps least likely to impact wildlife. The observed pattern of habituation by many species where flights are predictable is likely not to have time to take effect during an initial rig mobilization but may, provided flight paths are properly worked out and adhered to, provide for some habituation over the course of single or multiple drilling projects.

In summary, heliportable drilling has the potential to reduce, but not eliminate total environmental impacts compared to road accessed drilling in some areas. Low impact ground access may be less total impact in some valley areas near existing roads or trails. Heliportable drilling impacts are substantially shorter in duration than even aggressively reclaimed conventional drilling projects. In the case of a blow-out with large volumes of liquids, there would likely be a longer discharge time for the heliportable operation. The consequence of this will be dependent on site layout and contingency plans designed for this event. There appears to be a substantive opportunity to reduce the environmental impacts of exploration drilling using heliportable if mitigation measures and planned and implemented.

5.3 Field Development, Production and Operations

The development and production phase typically involves the drilling of additional reservoir delineation and production wells, construction and operation of pipelines and facilities (*e.g.*, well heads, dehydration facilities, compressors, refrigeration units, valves). During operations, well sites require periodic site visits and maintenance. While the use of a remotely operated Supervisory Control and Data Acquisition System (SCADA) can reduce the need for daily site visits (standard practice at sour facilities) ongoing operations at sour facilities (as would likely be required in the central portion of the MK) usually involves daily site visits. After the initial discovery, well reservoir characteristics and energy economics may or may not result in additional delineation and production drilling. In most cases, companies will seek at least one additional well within a structure. These wells typically have a much higher probability of success than the initial exploration well and may result in more complete and/or rapid reservoir depletion. At least once or more in the life of a gas well, it can be expected that a company will require a work-over rig to conduct further maintenance activities at a given well. This rig is typically truck-mounted and will be at a site for one or more weeks although these rigs could be adapted to helicopter transport.

The economic and productive lifespan of proven wells and therefore the duration of impacts associated with road or heliportable access for development and production purposes can range considerably depending on the characteristics of the gas reservoir, how aggressively the well is produced and energy prices. Some wells in the can be expected to produce for in excess of ten years while other wells may only produce for a year or so before watering out or becoming uneconomic.

5.3.1 Conventional Field Development, Production and Operations

The nature of impacts associated with conventional road-based development, production and operations are similar to those occurring during the exploration phase, however, once a project has entered this phase the impacts and demands on mitigation become more sustained in a given area. While human and likely predator access to pipeline rights-of-way can be controlled through the use of heavy rollback, the necessity to construct a pipeline opens up an unavoidable linear disturbance and impact to the landscape aesthetic.

5.3.2 Heliportable Field Development, Production and Operations

Some remote fields in western Canada are currently operated using seasonal air access with small helicopters (Hunley pers. comm.) In these cases, major servicing and modification is typically scheduled during the winter when low impact roads can be used. Advancements in technology and design have advanced to a point where well servicing can be achieved using heliportable equipment. Some potential may exist for helicopters to reduce the total width of clearing and habitat disturbance required for pipeline construction though the net environmental benefit is far from clear and would need to be examined carefully relative to more conventional, ground-based construction options (*e.g.*, shallow ditching, drilled segments, pre-weld carry-in segments). A more exhaustive analysis of these alternatives is beyond the scope of the present study.

5.4 Abandonment and Reclamation

Conventional well site and facility abandonment and reclamation requires use of heavy equipment for removal of equipment, earthwork to restore site grades and replace any salvaged topsoil and organic material. In the heliportable context, this requires use of smaller pieces of heavy equipment with the net effect that this process may be more prolonged. This would require the mobilization of heavy equipment similar to site preparation activities of a heliportable project. Reseeding and any silvicultural activities can be done using ATV's and/or on foot or using aerial seeding.

The environmental impacts of road-based vs. heli-based equipment removal could be considered short-term and more or less equivalent. The primary differences between the two options is that a heliportable drilled and produced well does not require reclamation beyond the well site, camp and any staging areas. Reclamation of roads associated with conventional access requires temporary de-stabilization of the road bed and movement of soils to restore grades and facilitate reclamation. In the course of doing this, the right-of-way becomes temporarily vulnerable to erosion though over the following one or two years the net effect is an overall reduction and eventual elimination of road related environmental impacts. Landscape scars associated with conventional road access being the longest term residual impact.

5.5 Summary of the Environmental Impacts Through the Life Cycle

The potential environmental impacts of conventional road accessed exploration compared with heliportable exploration drilling are presented in Table 7. It is clear that road development has by far greater potential for adverse environmental impact than a heliportable access scheme during exploration as well as during development under most circumstance. The difference between a heliportable play and a conventional play on vegetation, fish and wildlife can be significantly reduced where a low impact ground-based access approach is available (*e.g.*, snow road with minimal grading or clearing) such that differences could in some contexts be considered negligible. In a dry hole scenario, the impacts of more conventional road construction on wildlife and fisheries can be significantly reduced by full reclamation which incorporates extensive recontouring and heavy timber rollback (if available) though impacts to the wilderness landscape aesthetic remain for many years. These longer-term post-reclamation impacts are much reduced on a heliportable drilling program. Somewhat greater potential exists for environmental contamination caused by uncontrolled release of liquids during a blow-out at a heliportable well site than at a road accessed site unless this potential has been considered in pre-planning.

For producing wells, mitigation of human related impacts becomes reliant on: use of seasonal low impact road access; full access reclamation with follow-up access by helicopter; maintenance of conventional all weather access and strategically located access control/gate; or leaving the access open and relying on voluntary adherence and/or intensive and highly punitive enforcement.

TABLE 7

SUMMARY OF ENVIRONMENTAL IMPACTS DURING LIFE CYCLE

Conventional	Heliportable
TRANSPORTATION AND DRILLING - Access	
potential for watercourse crossings and associated impacts to fish habitat, riparian vegetation and water quality	no watercourse crossings or associated impacts
loss of vegetation communities and forest cover	no loss of vegetation communities and forest cover (unless access road is required between well site and nearby camp site)
greater direct loss of wildlife habitat (magnitude dependent on road length and location *e.g.*, 10 ha on 5 km x 20 m road)	no loss of wildlife habitat due to access (unless access road is required between well site and nearby camp site)
10 to 50 times indirect habitat loss where species are displaced from otherwise suitable habitat as part of a human avoidance response or barrier effects (*e.g.*, 100 ha to 500 ha if 5 km road buffered 100 m or 500 m respectively). Impact contingent on duration and intensity of road use	indirect habitat loss as wildlife may be temporarily displaced as a result of helicopter traffic/noise. Area dependent on flight path
increased species vulnerability to mortality from fishing, hunting and vehicle collision	no increased species mortality from fishing, hunting and vehicle collision
potential increased ungulate vulnerability to wolf predation	no increase in risk of ungulate vulnerability to predation
potential for high visibility, long-term terrain alteration	minimal high visibility terrain alteration
moderate term (1 month +), localized noise pollution associated with building access	no potential for increased visitation rates by various forms of recreational use
greater potential to interfere with first nations traditional resource use and cultural sites;	reduced potential to interfere with first nations traditional resource use and cultural sites
access control measures (*e.g.*, regulations, gates, monitoring) are required	access control measures are not required
greater direct loss of wildlife habitat (magnitude dependent on road length and location *e.g.*, 10 ha on 5 km x 20 m road)	no potential for increased visitation rates by various forms of recreational use

TABLE 7 Cont'd

Conventional	Heliportable
TRANSPORTATION AND DRILLING - Area Required for Well Site, Staging Area, Camp and Other	
well site is typically 1.4 ha (120 m x 120 m)	well site is typically 1.8 ha (120 m x 150 m)
no staging area.	staging area approx. 0.3 ha (70 m x 45 m).
no additional area required for helicopter landing and refueling.	helicopter landing and refueling area at the staging area and well site approx. (0.3 ha) 50 m x 60 m
camp site 0.1 ha (20 m x 50 m)	camp site 0.1 ha (20 m x 50 m)
borrow pits and log decks may be required for access road construction	borrow pits and log decks are not required for access road construction
Net initial disturbance approx. **1.5 ha**	Net initial disturbance approx. **3.5 ha**
TRANSPORTATION AND DRILLING - Season of Activity	
winter construction and drilling strongly promoted in the MK, reduces habitat impacts and potential long-term summer/fall access issues.	primarily in summer and fall
winter construction and drilling increases potential increased displacement of ungulates from winter range and energy expenditures	summer construction and drilling avoids critical winter periods for ungulates
winter access avoids conflict with most recreationists and guide outfitters	increased potential for short-term conflict with recreationists and guide outfitters and long-term conflict if daily heli-operations required.
TRANSPORTATION AND DRILLING - Duration of Activity	
requires longer term activity and associated disturbance to allow for road construction and potential need to suspend drilling if not completed by break-up.	reduced time for activity effects on wildlife as less time required for construction, not dependent on frozen ground conditions, less time for reclamation.
FIELD DEVELOPMENT, PRODUCTION AND OPERATIONS - Pipelines and Facilities	
pipeline will most often follow access road potential for watercourse crossings	new right-of-way will be required for pipeline potential for watercourse crossings
FIELD DEVELOPMENT, PRODUCTION AND OPERATIONS - Site Visits	
periodic disturbance to wildlife and recreationists caused by vehicular traffic to and from well site for well maintenance	periodic disturbance to wildlife and recreationists caused by helicopter traffic to and from well site for well maintenance
FIELD DEVELOPMENT, PRODUCTION AND OPERATIONS - Access	
ongoing access management required and access related issues	ongoing access management is not required
ABANDONMENT AND RECLAMATION - Access Road and Well Sites	
extensive reclamation required to restore grades, facilitate revegetation, restore creek crossings and control access (*e.g.*, rollback)	much less reclamation required (unless access road was required between well site and camp site)

6.0 MITIGATION MEASURES

Drilling in the sensitive MK by any method has potential for substantive environmental impacts depending on the site-specific impacts. A variety of tools or practices are available to mitigate the environmental impacts of road-based and helicopter-based exploration programs, examples of some of these options and potential constraints to their use are summarized in Tables 8 and 9.

TABLE 8

MITIGATION FOR ROAD-BASED EXPLORATION PROGRAMS

Mitigation Options	Constraint to Using Option
A Direct Habitat Loss Caused by Road Construction	
Route along existing linear disturbances.	Typically provide only partial access and usually require upgrades.
Winter only construction.	Short season, contingent on duration of freeze-up. Potential to encounter springs, need to complete in one season.
Minimal width ditchless construction.	Need storage area for end-hauled material or use for fill in hollows, requires more materials handling. Expensive and more time consuming.
End-haul cut material, avoid fill-type construction for access road.	Requires cold weather. May require two season drilling if late freeze-up or early break-up. Require water source for snow/ice making. May require site-specific fisheries investigations. Contingent on availability of matting. Typically require level ground.
Ice/snow road and well pads using creek beds, flood plains, meadows, wetlands and shrub terraces.	Require adequate water depths through entire drilling season. Require DFO approved landing design. Requires specific design, planning and production expenditure.
Use of plastic or wood matting.	Requires specific design, planning and production expenditure. Long-term recovery for forested habitats, expensive.
Expeditious and aggressive reclamation.	Time, variable site success, cost.
River barge access.	Size of watercourse and proximity to drilling location.
Platform rig construction to minimize well site construction disturbance (offshore style).	Requires detailed design and engineering.
Heavy lift tram construction.	Requires detailed design and engineering.
B Indirect Habitat Loss and Fragmentation Caused by Wildlife Displacement, Barrier Effects, Incidental Human Use	
Use existing linear disturbances.	Typically provide only partial access and usually require upgrades.
Strategic routing to avoid intensively used areas.	Habitat use patterns not always well known. Impossible to completely avoid. Residual impact may still be substantial.
Minimize total amount of vehicle and human use.	None during drilling with exception of occasional public use. Difficult to control in production. Reliant on enforcement and public support. Contingent on location of access and road relative to seasonal use patterns. Limited by terrain conditions. Long-term recovery for forested habitats, expensive. Variable degrees of public compliance can be expected. Considered of limited effectiveness where enforcement and monitoring is infrequent.
Schedule timing of drilling program outside of season of wildlife use.	May be long duration construction and drilling program. Delay of potential tie-in.
Minimize width of road.	Terrain conditions.
Restore large woody debris, slash berms and aggressively reforest with shrub and tree transplants.	Time, cost, availability of transplant stock.
Public education and signage.	Variable success, no effort of predators.
Gates/barriers.	Variable success, often defeated by persistent individuals. No effect on predators.

TABLE 8 Cont'd

Mitigation Options	Constraint to Using Option
C Increased Risk of Sedimentation and Contamination of Watercourses	
Use winter construction and drilling where feasible.	Unpredictable timing and duration of winter conditions.
Careful site selection.	Contingent on location of well site.
Follow optimal design standards for watercourse crossings.	
Ensure bridge length and culvert installation adequate.	None. Bridge cost/rental can be substantial.
Install silt fence and "diaper all water crossings.	None.
Use matting.	May be limited availability and or uneven ground conditions.
Ensure prompt wet weather shut down.	Delay. Is considerable pressure to continue use during drilling stage. Cost.
Avoid construction and drilling during freeze-up or breakup.	Delay. Is considerable pressure to continue use during drilling stage. Cost.
D Creation of New Access for Humans	
Gates, rollback.	May be challenged by small number of individuals. Gates likely to require frequent repair.
Require access removal, immediate reclamation on completion and tie-in followed by heliportable well servicing.	May be prolonged period before restoration of forest cover if well successful. Cost
Prompt reclamation on abandonment.	May be prolonged period before restoration of forest cover if well successful.
Public Education and signage.	Variable degrees of public compliance can be expected.
E Increased Wildlife Vulnerability to Hunting	
See measure in D above.	See constraints in D above.
Design access to avoid long sight lines and or to take advantage of existing open areas.	May be terrain constraints that limit this option.
F Creation of New Access for Predators	
Reclaim expeditiously and use aggressive whole-tree rollback.	Contingent on decision made to retain road for production.
G Interference with Guide Outfitter Operations	
Select least impact drilling location.	May be limited flexibility in potential drill site location.
Plan road access to avoid active outfitter areas and traditional campsites.	Outfitters tend to be active over broad areas and would likely be impossible to completely avoid. May be limited flexibility for some drill sites.
Schedule drilling activity outside of primary guide outfitting and recreation period.	Would require scheduling construction and drilling program from late fall through winter. This would have the benefit of allowing potentially lower terrain impact road and well site construction due to frozen conditions but would increase potential for displacement of wildlife from critical winter range depending onsite
Compensate outfitter for lost opportunity in area of impact over period of impact.	Assumes both parties amenable to arrangement.
H Impacts to Landscape Aesthetic	
Use existing linear disturbances.	Contingent on availability.
Winter construction and routing through existing clearing, creek beds, floodplains, shrub terraces.	Contingent on availability and duration of winter season.
Meander route through forested areas.	Contingent on well location.
Minimal width access.	None but contingent on well location.
Visual resource assessment and layout.	None but contingent on well location.

TABLE 9

MITIGATION FOR HELICOPTER-BASED EXPLORATION PROGRAMS

Mitigation Options	Constraint to Using Option
A Displacement of Stone's Sheep, Mountain Goat and Other Wildlife	
Select least impact drilling location.	May be limited flexibility in potential drill site location.
Plan flight paths to avoid sheep and goat habitat and adhere to MK flight guidelines.	May be limited flexibility for some drill sites. Weather conditions may impair compliance in some instances.
Avoid drilling during winter and during spring lambing/calving period.	Requires planning and scheduling to allow this. Some wells may require drilling later in the season.
Select lower noise helicopters.	Preferred machines may not always be available. Magnitude of benefit unproven.
B Noise Pollution and Interference With Guide Outfitter Operations	
Select least impact drilling location.	May be limited flexibility in potential drill site location.
Plan flight paths to avoid active outfitter areas and traditional campsites. Adhere to MK flight guidelines.	Outfitters tend to be active over broad areas and would likely be impossible to completely avoid. May be limited flexibility for some drill sites. Weather conditions may impair compliance in some instances.
Schedule drilling activity outside of primary guide outfitting and recreation period.	Would require scheduling heliportable drilling program from late fall through winter when day length is reduced and flying conditions are sub-optimal. This would have the benefit of allowing potentially lower terrain impact heliportable well site construction due to frozen conditions but would increase potential for displacement of wildlife from critical winter range depending on site location.
Compensate outfitter for lost opportunity in area of impact over period of impact.	Assumes both parties amenable to arrangement.
C Uncontrolled Release of Liquids During Blow-out	
Have contingency plan in place and ensure drilling crew are appropriately trained.	None.
Design site and plan emergency containment area to minimize potential for unrestricted flow.	Options at site for containment may be limited.
Ensure initial response heavy equipment and supplies either on site through drilling program or available on short notice.	Cost. Large bulldozers (e.g., larger than D6) exceed heli-transport capability. May require more pieces of smaller equipment. Does not resolve issue of fluids disposal.

7.0 CONCLUSION

Using helicopters for access to exploration wells in the MK will avoid the long-term direct habitat loss and impact to the wilderness landscape aesthetic associated with conventional road accessed drill sites. Heliportable drilling will, however, result in an increased level of noise pollution over the drilling period.

The indirect environmental impacts (displacement of wildlife and theoretical predator corridor effects) associated with road-accessed exploration programs which require extensive clearing and grading could be limited to the drilling period provided the winter access corridor is appropriately recontoured and reclaimed using aggressive application of timber and slash rollback. Biophysical conditions within the MK are also such that in some instances winter exploration roads could be built which would result in near equivalent habitat loss and long-term landscape aesthetic impact compared to heliportable drilling while avoiding the noise pollution, potential outfitter/recreationist interference and cost associated with it.

A range of mitigation measures are available to reduce the potential impacts of both a heliportable drilling operation and more conventional land-based access. The magnitude of difference in environmental impact between the two basic alternatives is site-specific and may range from negligible to very significant. While in most cases relatively less physical impact will be associated with heliportable operations there may be site-specific cases where these exceed that of conventional low impact winter road construction. An example of this circumstance would be a case where a snow or ice fill road with minimal clearing requirement could be constructed to a narrow valley bottom location adjacent to occupied sheep habitat.

A decision to allow road access during the production phase would negate the long-term benefits of heliportable drilling for successful wells. Where roads are constructed for long-term production potential indirect impacts on wildlife populations caused by displacement from human activity (as opposed to predator avoidance) could be minimized by reducing the level of human activity on these roads. This could be achieved by allowing winter only industrial use as well as gating combined with enforcement, monitoring and education programs to control public use. Further investigation of the costs and benefits of various forms of access during operations is warranted.

8.0 RECOMMENDATIONS

1. As a planning tool and to assist with decision making, it may be useful to identify and map the areas where the potential for low impact alternatives exist, as well as areas that may be more suited to helicopter access only (*i.e.*, designate as heliportable only). The varied topography, landforms, aspects and habitat community types within the MK create circumstances where heliportable drilling and/or low impact access road alternatives may be more or less suitable.
2. As many of the benefits of heliportable exploration drilling are eliminated where road access is developed, the practicality and economics of heliportable operations should be investigated and reported.

9.0 REFERENCES

9.1 Personal Communications

Adamson, Murray. Canadian Helicopters. Fort St. John, British Columbia.

Crowson, Randy. Parker Drilling. Houston, Texas.

Hunley, Tony. Airborne Energy Solutions. Calgary, Alberta.

Ziebell, Trevor. Murphy Oil Company Ltd. Calgary, Alberta.

9.2 Literature Cited

Alberta Sustainable Resource Development. 2001. Recommended Land Use Guidelines for Mountain Goat and Bighorn Sheep Ranges in Alberta. 3 pp. http://www3.gov.ab.ca/srd/fw/landuse/

Albrecht, S., R. Hinkle and K. Winship. 1999. Habitat fragmentation resulting from the construction of linear projects: Literature Review - Phase I. URS Greiner Woodward Clyde, New Jersey. Prepared for Gas Research Institute. Contract No. 5097-250-4070.

Antoniuk, T.M. 1994. Cumulative Effects of Natural Gas Development in Northeast British Columbia. In: Kennedy, A.J. (Ed.) 1994. Cumulative Effects Assessment in Canada: From Concept to Practice. Calgary, ASPB. 333 pp.

Bangs, E.E. and T.N. Bailey. 1982. Moose movement and distribution in response to winter seismological exploration on the Kenai National Wildlife Refuge, Alaska. Unpublished Final Report prepared for ARCO, Alaska, Inc. Anchorage, Alaska. 46 pp.

BC Government. 1997. The Muskwa-Kechika Management Plan. *Muskwa-Kechika Management Area Act*. Queen's Printer, Victoria, British Columbia, Canada.

BC Government. 1998. *Muskwa-Kechika Management Area Act*. Queen's Printer, Victoria, British Columbia, Canada. www.legis.gov.bc.ca/1998-99/1st_read/gov37-1.htm.

BC Hydro. 2001. Green and Alternate Energy, Wind Mapping and Modelling Initiative. http://www.bchydro.com/power_future/green/wind_mapping.html.

BC Ministry of Energy, Mines and Petroleum Resources. 1995. British Columbia Oil and Gas Handbook. ISBN 0-7726-2737-1.

BC Ministry of Environment, Lands and Parks. 1999. BC Wildlife Biophysical Data File. Habitat Suitability Maps. ftp://ftpfsj.env.gov.bc.ca/

BC Ministry of Environment, Lands and Parks and BC Ministry of Energy, Mines and Petroleum Resources. 1995. Upper Sikanni Management Plan. 33 pp. + appendices.

BC Ministry of Sustainable Resource Management. 2002a. Muskwa-Kechika Management Area Home Page. http://www.luco.gov.bc.ca/lrmp/mk/mk0301/index.html.

BC Ministry of Sustainable Resource Management. 2002b. Besa Prophet Pre-Tenure Plan. DRAFT.

BC Ministry of Water Land and Air Protection. 2001. 2001 and 2002 Hunting and Trapping Regulation Synopsis. http://monday.com/hunting/index.htm.

BC Parks. 2000. Muskwa-Kechika Management Area Recreation Plan. Draft, August 1, 2000. 69 pp.

Benn, B. 1998. Grizzly bear mortality in the Central Rockies ecosystem, Canada. Master's Degree Project. Faculty of Environmental Design, University of Calgary.

Bleich ,V.C., R.T. Bowyer, A.M. Pauli, R.L. Vernoy and R.W. Anthes. 1990. Responses of mountain sheep to helicopter surveys. Calif. Fish and Game 76(4): pp 197-204.

Bunnell, F.L., L. Kremsater and B. Boyland. 1998. An ecological rationale for changing forest management practices on MacMillan Bloedel's forest tenure. Centre for Applied Conservation Biology. University of British Columbia.

Cederholm, C.J. and E.O. Salo. 1979. Effects of logging road sedimentation on salmonid populations and their habitat. Univ. Washington, Fish. Res. Instit., 13 pp.

Coady, J. W. 1982. Moose. Chapter 46 in, Wild Mammals of North America, Ecology, Management and Economics. J. Chapman and G. Feldhamer Editors. Johns Hopkins University Press, Baltimore, MD. pp 902-922.

Cole, E.K., M.D. Pope and R.G. Anthony. 1997. Effects of road management on movement and survival of Roosevelt elk. J. Wild. Manage. 61. pp 1115-1126.

Cote, S.D. 1996. Mountain goat responses to helicopter disturbance. Wild. Soc. Bull. 24(4). pp 681-685.

Dyer, S. 1999. Movement and distribution of woodland caribou (*Rangifer tarandus caribou*) in response to industrial development in northeastern Alberta. Master of Science Thesis, University of Alberta. 106 pp.

Edge, W.D. and C.L. Marcum. 1991. Topography ameliorates the effects of roads and human disturbance on elk. Proceedings of a Symposium on Elk Vulnerability. Montana Chapter of the Wildlife Society. Montana State University, Bozeman, Montana. April 10-12, 1991. pp 132-137.

Environment Canada. 1982. Canadian Climate Normals 1951-1980, Volume 6 Frost Gel. Ministry of Supply and Services Canada. 276 pp.

Environment Canada. 2002. Average monthly temperature and precipitation values for Muncho Lake, BC 1970-2000.

Fort Nelson LRMP. 1997. Fort Nelson Land and Resource Management Plan. Government of British Columbia. 184 pp. including appendices and map.

Fort St. John LRMP Working Group. 1997. Fort St. John Land and Resource Management Plan. Government of British Columbia. 167 pp. + appendices and map.

Frid, A. 1998. Responses to helicopter disturbance by Dall's Sheep: Determinants of escape decisions. Prepared for Yukon Fish and Wildlife Branch, Dept. of Renewable Resources. Whitehorse.

Furniss, M.J., T.D. Roelofs and C.S. Yee. 1991. Road construction and maintenance. In, "Influences of forest and rangeland management on salmonid fishes and their habitats." American Fisheries Society Special Publication 19. pp 297-323.

Grubb, T.G. and R.M. King. 1991. Assessing human disturbance of breeding bald eagles with classification tree models. Journal of Wildlife Management. 55(3). pp 500-511.

Grubb, T.G. and W.W. Bowerman. 1997. Variations in breeding bald eagle responses to jets, light planes and helicopters. Journal of Raptor Research. 31(3). pp 213-222.

Guide Outfitters Association of British Columbia. 2002. http://www.goabc.org/02goabc/02economic.html.

Gunn, A., R. Glaholt, F.L. Miller, and K. Jingfors. 1982. Caribou behaviour, range use patterns, and short term responses to helicopter landings on the Beverly Calving Grounds, N.W.T. Government of the Northwest Territories, Dept. of Renewable Resources, Yellowknife. File Report No.30. 126 pp.

Harper, W.L. and D.S. Eastman. 2000. Wildlife and Commercial Backcountry Recreation in British Columbia: Assessment of Impacts and Interim Guidelines for Mitigation. Prepared for Wildlife Branch of BC Ministry of Environment, Lands and Parks. 80 pp.

Higgins, C. 2001. Impacts of roads and backcountry recreation on wildlife, fish and wildlife habitat values, An empirical overview. Muskwa-Kechika Trust Fund. Project No.: 96654 (MK 2001-45). 38 pp.

Horesji, B. 1975. Wildlife Studies. Section III. In: Baseline studies of the biology of streams and wildlife populations in the Sheep Creek drainage, Alberta. Aquatic Environments. Ltd. Crossfield, Alberta.

Huntington, C.W. 1998. Stream and salmonid assemblages within roaded and unroaded landscapes in the Clearwater river sub-basin, Idaho. pp 413-428. In M.K. Brewin and D.M.A Monita. Text coordinators. Forest-Fish Conference: Land Management Practices Affecting Aquatic Ecosystems. Proc. Forest-Fish Conf., May 1-4, 1996, Calgary, Alberta. Nat. Resources Canada. Canadian Forest Service Northern Forestry Centre. Edmonton, Alberta. INF. Report NOR-X-356.

Jalkotzy, M.G., P.I. Ross, and M.D. Nasserden. 1997. The effects of linear disturbance on wildlife: a review of selected scientific literature. Canadian Association of Petroleum Producers. Pub. #1998-0002.

James, A.R.C. and A.K. Stuart-Smith. 2000. Distribution of caribou and wolves in relation to linear corridors. J. Wildl. Manage. 64: 154-159.

Kasworm, W. and T. Manley. 1991. Road and trail influences on grizzly bears and black bears in northwest Montana. 8th International Conference on Bear Research and Management. pp 79-84.

Kasworm, W. and T. Manley. 1998. Grizzly bear and black bear ecology in the Cabinet Mountains of northwest Montana. Montana Department of Fish Wildlife and Parks.

King, D.I., R.M. DeGraaf and C.R. Griffin. 1998. Edge-related nest predation in clearcut and groupcut stands. Conservation Biology 12: 1412-1415.

Krausman, P.R. and J.H. Hervert. 1983. Mountain sheep responses to aerial surveys. Wild. Society Bull.11(4). pp 372-375.

Leptich, D.J. and P. Zager. 1991. Road access management effects on elk mortality and population dynamics. Proceedings of a Symposium on Elk Vulnerability. Montana Chapter of the Wildlife Society. Montana State University, Bozeman, Montana. April 10-12, 1991. pp 126-137.

MacArthur, R.A., R.H. Johnson, and V. Geist. 1979. Factors influencing heart rate in free-ranging bighorn sheep: a physiological approach to the study of wildlife harassment. Can. J. Zool. 57. pp 2010-2021.

MacArthur, R.A., V. Geist and R.H. Johnson. 1982. Cardiac and behavioural responses of mountain sheep to human disturbance. J. Wildl. Manage. 46. pp 351-358.

Mace, R. D., J. S. Waller, T. L. Manley, K. Ake, and W. T. Wittinger. 1999. Landscape evaluation of grizzly bear habitat in western Montana. Conservation Biology 13: 367-377.

Mace, R.D., J.S. Waller, T.L. Manley, L.J. Lyon and H. Zuuring. 1996. Relationships among grizzly bears, roads, and habitat in the Swan Mountains, Montana. Journal of Applied Ecology 33. pp 1395-1404.

Mackenzie LRMP. 2000. Mackenzie Land and Resource Management Plan. 400 pp.

Martz, L.W., and I.A. Campbell. 1980. Effects of a pipeline right-of-way on sediment yields in the Spring Creek watershed, Alberta. Canadian Geotechnical Journal. 17(3): 361-368.

Mattson, D.J. 1993. Background and proposed standards for managing grizzly bear habitat security in the Yellowstone Ecosystem. Cooperative Park Studies Unit, University of Idaho, Moscow Idaho. 17 pp.

Mattson, D.J., R.R. Knight, and B.M Blanchard. 1987. The effects of development and primary roads on grizzly bear habitat use in Yellowstone National Park, Wyoming. Int. Conf. Bear Res. and Manage. 7: 259-273.

McLellan, B.N. and D.M. Shackleton. 1988. Grizzly bears and resource-extraction industries: Effects of roads on behaviour, habitat use and demography. Journal of Applied Ecology. 25: 451-460.

McLellan, B.N. and D.M. Shackleton. 1989. Grizzly bears and resource extraction industries: habitat displacement in response to seismic exploration, timber harvesting and road maintenance. Journal of Applied Ecology 26: 371-380.

Meidinger, D. and J. Pojar. 1991. Ecosystems of British Columbia. BC Ministry of Forests. Special Report Series ISSN 0843-6452: no. 6. 330 pp.

Miller, F.L. and A. Gunn. 1979. Response of Peary caribou and muskoxen to helicopter harassment. Canadian Wildlife Service. Occasional Paper Number 40. 90 pp.

Morgantini, L.E. 1993. Prairie Bluff Bighorn Sheep Study. Final Report Part 2: Ecology, movements and distribution and the impact of industrial activities. Unpubl. Report. Prepared for Shell Canada Ltd. by Wildlife Resources Consulting Ltd. 39 pp.

Mueller, Cedar M. 2001. Distribution of Subadult and Adult Grizzly Bears in Relation to Human Development and Human Activity in the Bow River Watershed, Alberta. Master's Degree Project, Resources and the Environment Program, University of Calgary, Calgary, Alberta.

National Parks Conservation Association. 2000. Statement of Kevin Collins Legislative Representative National Parks Conservation Association on Access to National Parks Before the Subcommittee on National Parks and Public Lands U.S. House of Representatives Washington, D.C. July 20, 2000. www.npca.org/media_center/testimonies/testimony072000.asp.

National Parks Service (USDI National Park Service). 1994. Report on aircraft overflights on the National Park System. Chapter 5: Effects of Overflights on Wildlife. 5.1-5.27. Report to Congress. September 12, 1994.

National Research Council of Canada. 2002. Standard times of sunrise, local noon, sunset and twilight for 2002. Website: http://www.hia.nrc.ca/cgi-bin/HIA/sunmoon3.pl.

Oberg, P. 2001. Responses of mountain caribou to linear features in a west-central Alberta landscape. Masters of Science Thesis. University of Alberta. 126 pp.

Paquet, M.M. and R.A. Demarchi. 1998. Stone's sheep of the northern Rockies: The effects of access. Prepared for Foundation for North American Wild Sheep (FNAWS), Guide Outfitters Association of British Columbia (GOABC). 88 pp.

Paton, P.W.C. 1994. The edge effect on avian nest success: how strong is the evidence? Conservation biology 8:17-26.

Rost, G.R. and J.A. Bailey. 1979. Distribution of mule deer and elk in relation to roads. J. Wildl. Manage. 43 pp. 634-641.

Rothwell, R. L. 1979. Erosion control at stream crossings, Hinton-Edson Alberta, 1974-1975. Alberta Environmental Research Secretariat, Edmonton, Alberta. Report 1979/1.

Shank, C.C. 1979. Human-related behavioural disturbance to northern large mammals: A bibliography and review. Prepared for Foothills Pipe Lines (South Yukon) Ltd. Calgary, Alberta. 254 pp.

Sigler, J.W., T.C. Bjornn and F.H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Trans. Amer. Fish. Soc. 133: 142-150. As cited in Westworth and Associates.

Stelfox, J.B. and B. Wynes. 1999. A physical, biological and land-use synopsis of the boreal forest's Natural Regions of Northwestern Alberta. Forem Consulting Ltd. and Daishowa-Marubeni International Ltd.

Stemp, R.E. 1983. Heart rate responses of bighorn sheep to environmental factors and harassment. Masters Degree Thesis. Faculty of Environmental Design. University of Calgary, Calgary, Alberta. 314 pp.

Stockwell, C.A., G.C. Bateman, and J. Berger. 1991. Conflicts in National Parks: A case study of helicopters and bighorn sheep time budgets at the Grand Canyon. Biological Conservation 56. pp.317-328.

Stouder, S. 2002. Roads and Elk Hunting IN Bugle, March - April 2002. pp. 56-63. Rocky Mountain Elk Foundation.

TERA Environmental Consultants (Alta) Ltd. 1996. Environmental Assessment for the Husky Oil Operations Ltd. Sikanni c-53-J (d-54-J bottom hole)/ 94-G-3 Gas Exploration Project.

The Interagency Grizzly Bear Committee. 1997. Grizzly Bear Compendium. 48 pp.

Transport Canada. 2001. Civil Aviation Web Site: http://www.tc.gc.ca/CivilAviation/menu.htm.

MUSKWA-KECHIKA MANAGEMENT AREA HELIPORTABLE DRILLING FEASIBILITY STUDY

TECHNICAL REPORT

Prepared for:

BC Ministry of Sustainable
Resource Management,
Muskwa-Kechika
Advisory Board
and the
BC Oil and Gas Commission

Prepared by:

Randal Glaholt and Lois Pittaway

TERA Environmental Consultants
Suite 1100, 815 - 8th Avenue S.W.
Calgary, Alberta T2P 3P2

Brian Churchill

Chillborne Environmental Services
SS2 Site 22 Comp 23
Fort St. John, BC V1J 4M7

Harris Wheeler
AAEA Ltd.
Charlie Lake, BC V0C 1H0

June 2002
2555

EXECUTIVE SUMMARY

The technical feasibility of heliportable drilling depends in part on the availability of depth rated heliportable drilling rigs and the ability of helicopters to deliver a level of critical support necessary for mobilizing, drilling and completing a deep sour gas well. At least 4 heliportable rigs are available in western Canada and are reported to have capability to drill to 3,400 m depth. Heliportable rigs with capability to drill sour wells to in excess of 5,000 m are working in other parts of the world and can be mobilized via heavy transport aircraft if rapid delivery is required (assuming they are free to be released). Obtaining the services of these larger rigs would require longer pre-planning for mobilization. While re-configuring a conventional rig to be heliportable is technically feasible, and perhaps half the cost of constructing a new heliportable rig, the drilling contractors approached during this study believed the construction of a purpose-built heliportable rig was the more appropriate engineering solution.

A range of heavy-lift helicopters capable of mobilizing all components of heliportable rigs and providing adequate support during potential heliportable operations are available in western Canada. Carefully planning helicopter use is required to maximize the efficiency of rig moves in order to adequately control the overall cost, time and safety of a heliportable drilling operation.

Assessing the ability of a heliportable drilling program in the MK to provide adequate emergency medical response capability and well control capability has been viewed as a fundamental determinant to the technical feasibility of heliportable drilling. While it is technically feasible to provide 24-hour helicopter support to a heliportable drill site, barring some short hourly-duration, extreme weather conditions, it is apparent that numerous remote work sites exist in BC which do not have guaranteed 24-hour emergency access for long-distance medical evacuation and at the same time comply with requirements of the Workers' Compensation Board of BC (WCB). The WCB has expressly stated that it would not prohibit heliportable drilling or require guaranteed 24-hour emergency access, provided normal requirements for remote work site medical facilities are met. Providing 24-hour emergency site access via helicopter would require a range of specific installations, equipment, planning and permitting. A key factor in the occurrence of accidents on drilling programs is the level of worker experience, the quality of supervision and worker attitude. Significant reduction in the likelihood of worker injury on a heliportable drilling program can be achieved by ensuring high levels of experience and training for all rig personnel.

At present the probability of an uncontrolled blow-out during drilling appears to be in the range of 0.3 to 0.6 blow-outs/1,000 wells. The cause of most blow-outs during exploration drilling programs is human error. The potential to significantly reduce the risk of a blow-out on a heliportable drilling program could be achieved by requiring use of only highly trained and experienced crews and ensuring the well site has been stocked with adequate drilling supplies. In order to minimize the environmental risk associated with a blow-out at a heliportable well site, the site needs to be planned in consideration of blow-out response and management. In addition, risk could further be reduced by maintaining a reserve of at least three or more pieces

of heavy equipment on site (*e.g.*, one bulldozer, one crane and one back hoe). A protocol and arrangement for access to other heavy equipment and transport capability at least during more critical phases of the drilling program should also be in place.

During a blow-out where there is a perceived risk to human life, drilling crews are typically evacuated on foot outside of the immediate hazard zone via pre-determined routes. For a conventional road accessed well, the access road is not relied on as the primary emergency escape route but is instead among the alternatives depending on conditions at the time of the blow-out. With provision of adequately planned emergency escape routes (*e.g.*, via foot or hand-cleared ATV routes), temporary accommodations and an air trailer or trailers (for sour gas wells) an equivalent level of worker and equipment protection, as occurs at road accessed sites, can be achieved at a heliportable sour well.

In the event of a significant uncontrolled sour gas release where there is a perceived hazard to workers the rig is typically ignited after a short period in order to eliminate the sour gas hazard and facilitate well control operations. In properly managed situations the hazard associated with a sour gas blow-out at a heliportable drill site would be of short duration (*e.g.*, minutes) and the availability of long distance road access of no clear necessity. In rare cases where large volumes of sour water are being produced rig ignition may be delayed until such time as liquid streams can be diverted to a separator and gas ignition achieved. More prolonged use of emergency air equipment may be required in these circumstances in the immediate vicinity of the well site.

The science and techniques used for blow-out control has advanced significantly in recent years such that more immediate well control or partial control (where the flow can be directed) can be achieved more rapidly by capping the existing well bore than by drilling a relief well. Controlling most blow-outs can be achieved within a period of days, or in some cases weeks. Once the flow is stopped by capping, a second rig can be deployed in a less urgent fashion. All of the equipment used for well capping can be maintained on a heliportable site or quickly flown in for this purpose. In rare cases where the drill casing cannot be reached by excavation, a relief rig may still be required. Where a relief rig is deemed necessary for control of a blow-out, conventionally accessed drilling sites are at an advantage since the pool of available relief rigs is in theory much larger and these can be delivered onsite and assembled in a more timely fashion. For a heliportable drill site, providing relief well capability would require prior arrangement for a heliportable rig and paying standby charges or relying on assumed availability. Services of heavy-lift helicopter for a contingency relief drilling rig move are generally available on short notice. An alternate scenario involves construction of a conventional access road for relief well mobilization and incurring the associated environmental impacts.

A second major concern during a blow-out concerns the release of liquids. Release volumes of salt water and other liquids can at times be large. Conventional road accessed well sites afford the opportunity to rapidly mobilize heavy equipment and transport large volumes of liquids. This ability is not practically achievable on a heliportable well site but could be managed by contingency planning, proper site selection, ensuring proper site drainage, as well as having a reserve of heavy equipment on site or readily available for transport and assembly.

It is recommended that if heliportable drilling is ultimately promoted in the MK a set of best practices should be developed which would focus on the needs for overall heliportable planning and coordination, training requirements, supervision, environmental protection, blow-out prevention and response. The influence of underbalanced drilling on blow-out risk should be further evaluated. The potential applicability of emerging technology such as "casing drilling" to significantly extend the depth range and possible safety of heliportable rigs should also be further monitored and explored. These undertakings should be collaboratively pursued through the Canadian Petroleum Safety Council or equivalent provincial body.

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY i
1.0 INTRODUCTION 1
2.0 DRILLING RIG REQUIREMENTS AND AVAILABILITY 2
  2.1 Heliportable Drilling Rigs 2
  2.2 Conventional Rigs 3
    2.2.1 Conclusion 3
3.0 OTHER SERVICES AND EQUIPMENT 4
  3.1 Supervision and Crew Requirements 4
  3.2 Drilling Mud, Tubulars and Related Consumables 4
  3.3 Water and Water Well Rigs 5
  3.4 Sumps and Tanks 5
  3.5 Cementing 5
  3.6 Nitrogen Services 6
  3.7 Completions and Service Rigs 6
  3.8 Wireline Services 6
  3.9 Coiled Tubing 7
  3.10 Fracturing 7
  3.11 Drilling Camp 7
  3.12 Conclusion 8
4.0 HEAVY-LIFT HELICOPTER AVAILABILITY AND CAPABILITY 9
  4.1 Availability and Capability of Heavy Lift Helicopters 9
  4.2 Conclusion 10
5.0 HELICOPTER DRILLING SUPPORT SERVICES 11
  5.1 Conclusion 11
6.0 WELL SITE CONSTRUCTION AND RECLAMATION 12
  6.1 Conventional 12
  6.2 Heliportable 12
  6.3 Conclusion 13
7.0 PLANNING AND TIMING CONSIDERATIONS 14
  7.1 Planning and Approvals 14
  7.2 Scheduling 14
  7.3 Heliportable Lease and Staging Area Preparation 16
  7.4 Drilling Rig Mobilization and Demobilization 16
  7.5 Other Timing Considerations 17
  7.6 Conclusion 17
8.0 WELL CONTROL AND SOUR GAS BLOW-OUTS 18
  8.1 Probability of Occurrence 18
  8.2 Blow-out Prevention and Risk Minimization 19
  8.3 Blow-out Response 20
    8.3.1 Site Evacuation 22
    8.3.2 Management of Released Sour Gas and Liquids 22
  8.4 Blow-out Control Using Relief Rigs 24
  8.5 Underbalanced Drilling 24
  8.6 Conclusion 25
9.0 24-HOUR EMERGENCY MEDICAL RESPONSE 26
  9.1 Conclusion 27
10.0 WORKERS' COMPENSATION BOARD OF BC 28
  10.1 Conclusion 28

11.0 PIPELINE AND FACILITY CONSTRUCTION 29
11.1 Conclusion 29
12.0 OPERATIONS 30
12.1 Conclusion 30
13.0 Abandonment 31
14.0 RECOMMENDATIONS 32
15.0 REFERENCES 33
15.1 Personal Communications 33
15.2 Literature Cited 34

LIST OF APPENDICES

Appendix A Type and Availability of Heliportable Rigs 35
Appendix B Capability and Availability of Heavy and Medium Lift Helicopters in North America 36

LIST OF FIGURES

Figure 1 Technical Factors Influencing Heliportable Drilling 1

LIST OF TABLES

Table 1 Tasks Associated with a Heliportable Drilling Program 15
Table 2 Drilling Blow-Outs in Alberta and British Columbia 1992-2001 18

LIST OF PLATES

Plate 1 Chinook 234 heavy lift helicopter (photo courtesy of Helifor Industries Limited). 9
Plate 2 Part of disassembled tractor to be transported via helicopter (photo courtesy of W. Sawchuck). 12

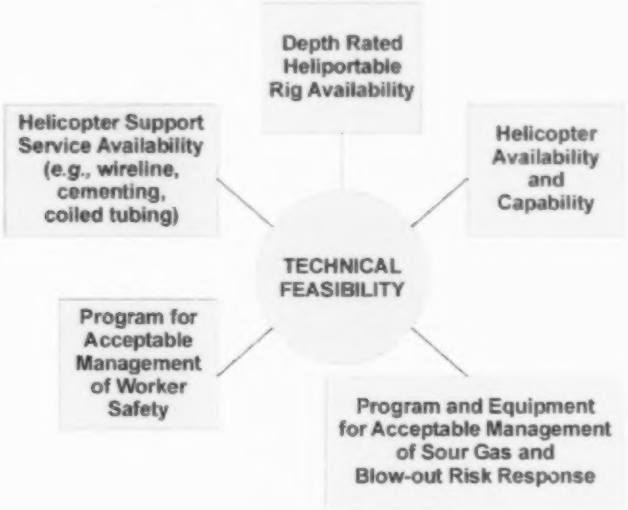
1.0 INTRODUCTION

The technical feasibility of an exploratory heliportable drilling operation is dependent on whether or not the transportation needs associated with lease construction, rig mobilization and drilling can be met using helicopters as the primary means of site access. Important technical considerations for heliportable drilling in the Muskwa-Kechika Management Area (herein referred to as the MK) include the following (see Figure 1):

- the availability of heliportable rigs and support equipment suitable for the geological conditions encountered in the MK;
- the availability of helicopters which can lift the anticipated range of loads under the conditions that may be anticipated during a typical drilling program in the MK;
- the ability of helicopters to provide adequate support during the drilling and completions process;
- the ability to effectively avoid and manage emergency medical response; and
- the ability to effectively avoid and manage blow-outs.

Each of these considerations is discussed in the sections that follow. Discussion is also provided concerning the technical feasibility and considerations associated with helicopter-based production, operations and abandonment.

Figure 1 **Technical Factors Influencing Heliportable Drilling**


Depth Rated Heliportable Rig Availability
Helicopter Support Service Availability (e.g., wireline, cementing, coiled tubing)
Helicopter Availability and Capability
TECHNICAL FEASIBILITY
Program for Acceptable Management of Worker Safety
Program and Equipment for Acceptable Management of Sour Gas and Blow-out Risk Response

2.0 DRILLING RIG REQUIREMENTS AND AVAILABILITY

The size of a drilling rig required for deep gas drilling within the MK in part, depends on the drilling target. As discussed in Section 2.2 of the Environmental Report, there are three potential geological formations of interest within the MK. These are the Mississippian, Triassic and Devonian. The deeper Devonian drilling targets (Pine Point) typically range in depth from approximately 2,500 m to 5,000 m (Ziebell pers. comm.). The deeper the target, the larger the required drilling rig to handle the weight of the drill string and to meet the mud circulation requirements. The larger components in turn, have the potential to limit the rig availability for deeper wells. In Murphy Oil Company's analysis of rig requirements for its initial Chicken Creek well in the southern MK it was determined that, after consideration of the disturbed, fractured and steeply dipping nature of the formations as well as anticipated high pressures of any gas present, that a rig rated for 3,500 m was required to provide adequate pumping and hoisting requirements to drill a well with a measured depth of 2,760 m (Murphy 1996). For the Imperial Oil Limited (IOL) well near Belcourt Creek (also subject to a heliportable drilling feasibility study) it was determined that a minimum 3,000 m depth rated rig would be required (IOL 1995).

2.1 Heliportable Drilling Rigs

What have been typically referred to as heliportable rigs are drilling rigs that can be broken down into relatively small weight packages that can be transported by heavy-lift helicopters. Heavier single component weights of conventional rigs such as draw-works, mud pumps, mud tanks and generator sets can weigh between 31,750 and 40,825 kg (70,000 and 90,000 lb). At the present time, the maximum rig package size that can be transported by readily accessed heavy-lift helicopters is about 11,000 kg (24,000 lb). Available heliportable rigs have been specifically designed with component weights below this weight limit. At the time of this review, there are four heliportable rigs in western Canada with the remainder operating in South America and the South Pacific region (see Appendix A). Western Canada rig availability for moderate drilling depths (*e.g.*, 3,400 m) appears to be greater than for deeper drilling.

Companies which maintain heliportable rigs include Drillers Technology Corp. (four heliportable rigs), Parker Drilling (15 heliportable rigs) and Helmerich and Payne Drilling (three heliportable rigs) (see Appendix A). The location of these rigs varies depending on rig demand in both North America and abroad. Many of the international rigs have maximum depth ratings in excess of 5,500 m. Maximum depth ratings of heliportable rigs available in western Canada is about 3,400 m.

The advent of "Casing Drilling", where the hole is drilled with casing instead of drill pipe has potentially broad significance to the drilling industry (Journal of Petroleum Technology 2001) and significant implications for heliportable drilling feasibility. For example the depth capability of a 3,400 m depth rated heliportable rig could potentially be increased from 3,400 m to 4,500 m using casing drilling (Pare. pers. comm.). This technology is very new to the industry but has been claimed to potentially reduce drilling time by as much as 30% and be safer (Oil and Gas

International 2002). At the present time, this technology is reported to be best suited to drilling softer formations with larger casing sizes (Journal of Petroleum Technology 2001).

Slim hole heliportable rigs (3 3/8" inch final hole size) are apparently available with 3,000 m depth capability and are many times smaller than rigs designed for conventional sized well bores (Hunley pers. comm.). These rigs have a number of constraints and may or may not be practical for heliportable drilling in the MK.

2.2 Conventional Rigs

Conventional drilling rigs are typically broken down into the fewest loads that can be moved by truck transport on local roads. The weights and loads associated with conventional drilling rigs are largely dependent on the drilling depth required such that deeper wells require larger components. Individual rig packages have been, in part, designed with the fewest components possible that can be moved by available heavy haul truck transport. As discussed above, the weights involved far exceed the lift capacity of heavy-lift helicopters (maximum 10,885 kg or 24,000 lb).

During the course of consultations undertaken for this study, it was suggested that in theory, any conventional drilling rig can be broken down into smaller package sizes such that they can be made to be heliportable. To the extent this is true, then rig availability becomes a non-issue from a technical perspective. During discussions with the larger North American drilling contractors (Parker Drilling and Precision Drilling) it was acknowledged that while conventional rigs could be broken down, this would be relatively expensive and time consuming. By one estimate, this conversion would take perhaps 4 to 6 months and could cost $5 to $8 million CDN (Crowson pers. comm.). This approach would require taking a conventional rig out of service for the additional time required to modify it and then to re-assemble it following the drilling program, unless it was to remain as a heliportable unit. Custom building a large heliportable rig from the ground up was roughly estimated to cost between $12 million and $30 to $33 million CDN (Pare, Crowson pers. comm.). Drilling contractors believe that modifying a conventional deep capability rig to be heliportable is less desirable than specifically designing a rig to this purpose.

2.2.1 Conclusion

There are currently 4 heliportable rigs with capability to drill sour gas wells to 3,400 m depth available in Canada. A relatively large pool of deeper-rated heliportable rigs are available elsewhere in the world that would allow drilling sour gas wells to in excess of 5,500 m. Contingent on availability, these rigs can be transported from these more remote locations by large cargo aircraft. Mobilization charges for an international rig could range from $1.5 million to about $2.5 million. Drilling deeper wells will require scheduling/reserving a deeper rated rig, undertaking specialized modifications to an existing conventional rig or planning the construction of a completely new heliportable rig. Both of these latter two options would be less time and cost effective than mobilizing a rig from a remote location.

3.0 OTHER SERVICES AND EQUIPMENT

A broad range of technologically advanced, purpose-built heliportable equipment has been developed by the industry in Western Canada to support and service typical wells that may be drilled in the shallower Mississippian and Triassic formations encountered in the MK and which may also be adaptable to deeper plays (Hunley pers. comm.).

3.1 Supervision and Crew Requirements

In the interest of absolutely minimizing the onsite risks at a heliportable well site, it is imperative the drilling contractor has staffed the drilling rig with personal that are fully trained and have been made aware of the sensitivity of the area and anticipated drilling conditions. The supervision and crew requirements should be modeled after offshore standards in this regard. Drilling rig crews should be structured so as to ensure that maximum experience is available at all times. It is with this in mind the following rig crew structure should be considered.

- Rig Foreman: Responsible for the overall operation and maintenance of the rig and all related equipment, whether owned, rented, leased or contracted. He will also be responsible for the handling of drilling crews made up of the following personal for each tower.
- Tower Push: answers directly to the Rig Foreman.
- Driller: responsible for the drilling crew under the direction of the Tower Push.
- Assistant Driller: assists the driller and derrick man.
- Derrick man: responsible for the drilling fluid and related equipment as directed by the driller.
- Motorman: as directed by the driller.
- Rough necks (2): as directed by the driller.
- Lease Hand: general roustabout as directed by the driller.

All crew members should have demonstrated advanced experience in the area of responsibility.

3.2 Drilling Mud, Tubulars and Related Consumables

No technical limitations are associated with the provision of typical well supplies such as drilling mud or drill string components. In a heliportable drilling program, the key element in this regard involves ensuring that both anticipated and backup supplies are stockpiled on site in order to allow management of contingencies and minimization of down time. The diverse range of seasonal operating constraints and site conditions encountered by the oil and gas industry has resulted in the significant advancement in the service industries ability to provide a range of portable equipment and rapid service response to remote locations. The key services required during drilling programs are discussed in the subsections which follow.

3.3 Water and Water Well Rigs

Provision of water for drilling can either be met through pumping from a local surface water source to the well site or drilling a separate water well. In a conventional drilling program, options for hauling from more remote sources are much more feasible than a heliportable option where a heavy-lift helicopter would be required for long-term support. Pumping over particularly long distances becomes more complex at below zero temperatures, though problems associated with freezing could likely be resolved by various means.

Conventional water well drilling rigs weigh in the vicinity of 5,000 kg (11,000 lb) to 24,545 kg (54,000 lb) depending on the size of the rig (Sroka pers. comm.). During discussions with water well drillers, it was apparent that all of these rigs could likely be stripped down for helicopter transport. An air-drill rig as opposed to a water/mud type, may be required depending on the availability of water for water well drilling purposes. A 1-ton truck-mounted water well drilling rig with capability to drill a 30 m (100 ft.) to about 76 m (250 ft.) well could be stripped down to about a 5,000 kg maximum package weight (Sroka pers. comm.). This same rig could be used to establish a conductor hole to at least 12 m (40 ft.) depth. In order to mobilize this equipment, the water well would need to be broken out into 5 or 6 helicopter loads (*e.g.*, rig, drill pipe, compressor, mud pump, air hammer). While somewhat slower, cable tool rigs weighing in the vicinity of 5,454 kg (12,000 lb) and capable of drilling to 91 m (300 ft.) are also available (Wolford pers. com.). Drilling a water well with these rigs could take 2 to 5 days. These same cable tool rigs can also be modified to drill up to 50 cm (20") conductor holes.

3.4 Sumps and Tanks

The use of open tanks for collection of drilled solids will help reduce the risk of ground contamination. These would be used in conjunction with a "high G" shaker and centrifuge system to ensure solids are dry. Fluids would be returned to the active system or a storage tank until ready for re-use. The decision to land farm solids onsite or have them removed to a remote location would be best made on a site specific basis. In the latter case, costs for heli-transport of solids would have to be considered. A number of 400 bbl tanks would be required to store additional fluid and fuel stockpiles. Spare tankage would be used in the event of a lost circulation problem or for well control in the event of an influx of formation water into the well bore.

3.5 Cementing

Heliportable electric or diesel mud pumps with up to 2000 Hhp capacity can also be used for cementing or alternately an independent unit could be used for the re-circulating cement mixing system. These skid-mounted units are available in both Canada and the US. Heliportable fluid pumping units (maximum pumping rate is 0.520 m^3/min, pressure is 10,000 PSI, maximum lift of 3400 lb) specifically designed to be heliportable are available in western Canada and can be transported by a Bell 205 in 4 loads (Hunley pers. comm.).

3.6 Nitrogen Services

Nitrogen pumping services are a critical component of the bundle of services associated with servicing a completed well. It is often used in association with a coil tubing unit. Nitrogen is used during the servicing of wells. When there is gas produced in association with liquids and the threat of combustion exists, nitrogen, as an inert gas, is used to service the well in place of air. Heliportable cryogenic nitrogen pumping units (maximum pumping rate of 85 m^3/min and pressure of 10,000 psi) are available and can be transported by a Bell 205 in three loads (plus tanks) (Hunley pers. comm.).

3.7 Completions and Service Rigs

Well completions are undertaken at such time as a well has proven successful and requires installation of a range of down hole equipment (*e.g.*, tubulars, packers) or perforation below the well head to enable long-term production. Typically a truck-mounted completions rig or service rig is deployed for this purpose. Heliportable drilling operations rely on the primary drill rig for this function. Subsequent well servicing required once the well is tied in would involve bringing in a conventional truck-mounted rig where road access was subsequently developed following the discovery or flying in a heliportable rig if no production road was built.

Heliportable electric line units are available in Western Canada and have been used many times. These units perform logging and perforating services required in well completions, are skid mounted and intended to be helicopter deployed. These units are deployed with a Hughes 500 helicopter (Hunley pers. comm.).

Heliportable derricks are also available, and have been used in oil production operations, for rod pulling to service a producing oil well. There is a significant amount of well testing equipment that is heliportable as well. Specifically designed and off-the-shelf heliportable flow testing equipment including: gas water ratio testing equipment, separators, tanks, surface data acquisition systems, flares etc are available. This equipment has all been used in remote applications, deployed by helicopters. Helicopter deployment is usually with a Robinson 44 or a Bell 206 helicopter.

3.8 Wireline Services

Wireline services can be required to lower mechanical tools (*e.g.*, valves, logging equipment, fishing equipment) into the well bore for various purposes. Single component weights for portable wireline services used in offshore operations can weigh in the vicinity of 8 metric tons (Matheson pers. comm.). Heliportable slickline and electric line units have been designed and are in current use in Alberta and BC. Maximum depth for slickline operations is 2,500 m. These units can be moved with a Robinson 44 or Hughes 500 helicopter, depending on unit size (Hunley pers. comm.). Wireless down hole tools which can be attached to the drill pipe weigh considerably less. In either case, it appears wireline services can be adapted to a heliportable drilling program.

3.9 Coiled Tubing

Coiled tubing is typically inserted into the well bore to convey gas to surface and for pumping methanol down hole where the well has frozen in. In the event road access was not allowed for the purpose of production, there are some implications for the use of continuous coiled tubing on a heliportable well. Continuous or endless coiled tubing is preferred due to the speed at which it can be run, as well as having somewhat greater integrity than jointed tubing. A 2-inch production tubing weighs approximately 4 kg/m. A 3,000 m deep heliportable well would require a 12,000 kg spool of tubing and require perhaps four trips to transport the associated injector, power pack and work spool (Thatcher pers. comm.). Tubing weights go up considerably as diameter increases. For example, two 7/8" tubing weighs 8 kg/m and its use, without welding, would restrict drilling depth to about 1,500 m. Heliportable continuous coiled tubing units capable of >2,000 m depth service are in production (Hunley pers. comm.). For deeper holes, tubing would have to be welded together. While less preferred, this practice is not uncommon.

Shallow (950 m 1" CT) and intermediate (2,400 m 1" CT) depth coil tubing units, specifically designed to be heliportable are available. The shallow units can be transported by a Bell 205 in seven loads including tank and flow line, while the intermediate unit will require a Vertol 107 (Hunley pers. comm.).

3.10 Fracturing

Formation fracturing is typically done as part of completions or work-overs to facilitate flow of gas or oil out of the formation. Conventional fracturing units are truck mounted and weigh in the vicinity of 24,040 kg (53,000 lb). Heliportable skid-mounted fracing units are available from various suppliers. Haliburton Energy Services, for example has diesel powered fracturing pump units up to 2000 Hhp which would could be broken down into 9,091 kg (20,000 lb) packages (Braden pers. comm.).

3.11 Drilling Camp

Modular components of conventional rig camps can range between about 9,000 kg (20,000 lb) for an 11 x 40 ft. accommodation unit to about 15,900kg (35,000 lb) for a kitchen or washroom unit (Clark pers. comm.). While these heavier units exceed helicopter lift capability, they can be further modified to reduce weights to be readily transportable by heavy-lift helicopters and they do not pose a technical constraint on heliportable drilling. Portable gray and black water treatment and/or containment facilities would be required at remote campsites. As an alternate approach to this, the camp could be located at the road accessible staging area. In this latter case, regular helicopter transport would be required for crew changes.

3.12 Conclusion

All normal, supporting well services can be adapted to heliportable service. From a tubing perspective, heliportable wells 3,000 m deep or less which can be adequately served by 2-inch tubing lend themselves to heliportable service slightly better than deep wells or wells requiring larger diameter tubing, since this would avoid having welded sections.

4.0 HEAVY-LIFT HELICOPTER AVAILABILITY AND CAPABILITY

4.1 Availability and Capability of Heavy Lift Helicopters

Helicopters have been used for drilling rig moves on a large number of wells worldwide. For example, Columbia Helicopters of Portland, Oregon has completed over 150 drilling rig moves using helicopters, including four in the United States (Peterson pers. comm.). Within North America, there are a number of heavy lift helicopters that have or could be used for mobilization and servicing of a heliportable drilling rig. A list of heavy and medium lift helicopters are listed in Appendix B. In North America, heavy-lift helicopters are primarily engaged in heliportable logging and other specialized remote heavy-lift requirements.

Early heliportable rigs were initially designed to be flown using relatively small helicopters such as the Super Puma and Boeing Vertol 107. Individual package weights were in the 3,600 kg range (Crowson pers. comm.). Development of larger lift capacity helicopters has increased the efficiency of heliportable rig moves considerably. The primary heavy-lift helicopter for heliportable rig moves is the Boeing Chinook 234 (Plate 1). The Chinook 234 generally works with loads ranging from 8,165 to 10,886 kg (18,000 to 24,000 lb). There are a total of 11 Chinook 234 helicopters in the commercial fleet worldwide. Of these, eight are owned by Columbia Helicopters and five are operating in North America (Peterson pers. comm.). Scheduling for Chinook 234 service would ideally involve approximately two months of lead time, however, where quick response is required, a machine can be onsite within one or two days (Peterson pers. comm.).

Plate 1 Chinook 234 heavy lift helicopter (photo courtesy of Helifor Industries Limited).

Other generally available heavy-lift helicopters include the Sikorsky S-64 Model E and F. Model E has a lift capability of 6,350 to 7,711 kg (14,000 to 17,000 lb) and Model F has a lift capability of 7,257 to 9,525 kg (16,000 to 21,000 lb). The Vertol 107 has a lift capability of 3,175 to 4,082 kg (7,000 to 9,000 lb) (see Appendix B). To maximize efficiency, it has been suggested that it is best to select the primary heavy-lift helicopter on the basis of the majority of loads rather than use an excessively large helicopter which may only be required for relatively few loads (Taylor pers. comm.). During the actual drilling program, the need for heavy-lift helicopters is not required and medium lift helicopters such as the Bell 212 or potentially an A-Star become more practical. These helicopters are usually readily available from helicopter companies operating in Fort St. John and Fort Nelson.

4.2 Conclusion

A range of helicopters with significant lift capacity suitable for heliportable drilling rig moves are available in North America. While these helicopters are available, careful planning would be required to ensure that the necessary machines are available as soon as drilling approval has been obtained and heavy equipment is ready to transport for lease construction.

5.0 HELICOPTER DRILLING SUPPORT SERVICES

Conventional drilling programs rely on vehicle transport to deliver drilling mud, additional drill pipe and drilling tools, haul fresh water and waste water, to ferry crews to and from road accessed staging areas and for emergency evacuation/medical emergencies.

A heliportable drilling program would involve use of helicopters for these same functions. A key aspect of efficiently managing a heliportable drilling operation is ensuring sufficient stockpiles of all essential supplies, fuel and equipment, including that for contingencies are onsite as part of the initial rig mobilization. Once heavy-lift helicopter requirements have been met, practical needs for crew moves, mud, drill pipe (etc.) and other supplies can be met with smaller helicopters. The Bell 212 and Sikorsky S-61 has been identified as good intermediate helicopters for this purpose and could be supplemented with an A-Star or Bell Jet Ranger for backup. Daily fuel consumption for drilling operations can be in the range of 11,356 litres to 18,927 litres (3,000 to 5,000 gallons) per day and as such potentially require multiple trips with a medium lift helicopter or one single lift with a Chinook 234 (Crowson pers. comm.). In discussions with Columbia Helicopters, it appears that most heliportable drill sites are serviced by a single helicopter (Peterson pers. comm.). In addition to ensuring service helicopters are properly equipped to maximize their operating window, adequate stockpiling of equipment, supplies and consumables at the drilling site is required to minimize any problems associated with no-fly conditions caused by weather and/or mechanical problems. Most large commercial helicopter companies have expertise (loadmasters) to manage and organize loads to make the process more efficient.

5.1 Conclusion

Routine drilling support services can be effectively provided by medium-sized helicopters. Considerations in respect of emergency response capabilities are discussed further in Sections 7.0 and 8.0.

6.0 WELL SITE CONSTRUCTION AND RECLAMATION

6.1 Conventional

Well site construction requires the transport of heavy equipment and fuel to the well site. For conventional lease construction, the same equipment used for access construction is also used for lease construction and reclamation and typically includes large bulldozers (*e.g.*, D8's) and track hoes. With this equipment, lease construction can take anywhere from one week to one month or more, depending on difficulties associated with the site. During reclamation, equipment is brought in as required. Somewhat smaller equipment may be used for this purpose. The time required for reclamation is roughly similar to that required for construction, depending on needs for special soil handling or cleanup and restoration.

6.2 Heliportable

Plate 2 Part of disassembled hoe to be transported via helicopter (photo courtesy of W. Sawchuck).

The mainframe components of typical heavy equipment (*e.g.*, D7 and larger bulldozers) used for lease construction substantially exceeds the lift capacity of heavy-lift helicopters. Typical heliportable drilling operations rely on smaller earth moving equipment such as D5 or D6 caterpillar tractors and smaller back hoes (*e.g.*, CAT 229 or equivalent). Transporting a D6 caterpillar tractor via helicopter typically requires removal of the track prior to transport. Use of this smaller equipment can be expected to somewhat lengthen the time for lease construction depending on site conditions. Relatively large conventional hoes (*e.g.*, CAT 330) can also be disassembled into heliportable loads (Plate 2). Heliportable 30 to 40 ton cranes are among the first pieces of equipment transported in order to facilitate the assembly of heavy equipment and the heliportable drilling rig. Lease construction time will be extended to the extent a larger lease is required at a heliportable site to accommodate heliportable operations, a potential camp and extra stockpiles of drilling supplies.

Fuel bladders are often used for onsite fuel storage at heliportable sites. From a practical perspective the heavy-lift helicopter deploying the lease construction equipment could make the initial fuel supply. In this regard, a Chinook 234 can transport approximately 3,000 gallons of fuel. Given that lease construction could take up to a month, it may be more practical to release the heavy-lift helicopter until the site is ready for the rig move and carry out any refueling or other service needs using a medium lift capacity helicopter. A Bell 212 can transport approximately 450 gallons of fuel and may be a reasonable choice for both the construction and drilling phase. Fuel consumption in the range of 3,000 to 5,000 gallons/day is not uncommon on a typical drilling program. Chinook helicopters are also used for fuel supply on many international heliportable drilling programs (Crowson pers. com.).

Once the site is prepared, heliportable 30 to 40 ton cranes are the next pieces of equipment transported in order to facilitate the assembly of the drilling rig, camp and other heavy equipment. A decision needs to be made as to whether some of the original lease construction equipment is stored onsite for the drilling period, or is removed and brought back once the site is ready to be reclaimed. Maintaining some equipment (*e.g.*, a bulldozer, track hoe and crane) would provide some contingency in the event of a spill or blow-out and also avoid the additional charges for heavy-lift helicopter moves for redeployment during reclamation. This would be partially offset by standby charges for that equipment during the 3 to 4 month anticipated drilling cycle.

6.3 Conclusion

Well site construction and reclamation is technically feasible using helicopter support though can be expected to take additional time for completion due to limitations on equipment size and potential requirement for a larger lease area. In a helicopter supported operation, there is a greater practicality in retaining some heavy equipment (*e.g.*, one small bulldozer and at least one crane) onsite to provide for immediate contingency response.

7.0 PLANNING AND TIMING CONSIDERATIONS

7.1 Planning and Approvals

Conventional drilling programs in more environmentally sensitive areas typically have long planning and approval times associated with them due to the requirement for more intensive site selection, design and consultation. Much of this effort is associated with the access route. Long roads, involving new cut, particularly where these traverse watercourses and other sensitive habitats or landscapes typically require much longer pre-planning time frames. Site-specific studies are often required to address engineering and geo-technical constraints, critical fish and wildlife habitat protection, archaeological resource potential, and First Nations concerns. This necessary pre-planning can frequently take up to six months or more depending on the site sensitivity and level of public and First Nations concern and consultation. Concern over local environmental sensitivities in the MK have typically required companies to schedule drilling programs during the winter period in order to facilitate low impact construction in some areas. In mountainous areas, road construction may take up to one week per kilometer of access.

In a heliportable application, it is assumed that less time would be associated with pre-planning site investigations, consultation and approvals once some initial local experience in this drilling technique has been gained. Scheduling a heliportable drill during the summer helps maximize the available daytime flying hours and improving potential emergency response.

7.2 Scheduling

The logistical organization and scheduling of a heliportable drill affects the overall time for execution, cost and safety of the drilling program. The steps involve survey and preparation of the road accessible staging area, construction of the lease and camp area and any interconnecting roads, establishment of the camp, rig mobilization and set up, drilling, rig and camp demobilization, reclamation, or production facilities construction. These steps are summarized in Table 1.

TABLE 1

TASKS ASSOCIATED WITH A HELIPORTABLE DRILLING PROGRAM

Task No.	Task
1	Schedule/reserve drilling rig.
2	Contract and schedule heavy-lift helicopter services.
3	Prepare road accessible staging areas for heavy equipment, rig components and supplies.
4	Prepare nearby dust free staging area for heavy-lift helicopter (approximately 70 m x 45 m).
5	Hand clear landing area, heavy equipment drop off site and refueling area at proposed campsite (assumes camp and well site are both heliportable locations in relatively close proximity (*e.g.*, within 1 to 2 km)).
6	Prepare helipad and heavy equipment refueling area at campsite.
7	Transport lease and camp construction equipment (*e.g.*, D5, D6, CAT 229 hoe) and fuel to site via heavy-lift helicopter.
8	Release heavy-lift helicopter until the drilling rig move. Service construction site with medium or light lift helicopter (*e.g.*, 212, A Star).
9	Prepare the campsite first followed by the lease site or bring in additional equipment to work on both concurrently.
10	Reposition heavy-lift helicopter once camp and lease site prepared.
11	Transport 1 or 2, 30 ton to 40 ton cranes to the lease site and assemble.
12	Heli-transport camp, rig and supplies to site.
13	Remove most/all lease construction equipment on return trips (back hauls). (may want to leave one crane and two pieces of heavy equipment onsite for emergency response)
14	Release heavy-lift helicopter.
15	Complete drilling program with medium-lift helicopter.
16	Disassemble drilling rig and campsite for heli-transport.
17	Reposition heavy-lift helicopter and return drilling rig, camp and non-essential equipment to road accessible staging area.
18	Use heavy-lift helicopter to transport reclamation equipment back to lease site for reclamation if equipment not kept on site through drilling program.
19	Reclaim the lease site.
20	Use heavy-lift helicopter to return reclamation equipment to staging area.

The helicopter company must supply experienced loadmasters at both staging area and drill site (Taylor pers. com.). All personnel must have good radio communication (including being able to contact the helicopters en route). All loads must be weighed and marked before being transported by helicopter. There should be a designated drop site at the staging area and the drill site unless a load has to be placed in a specific spot. It is recommended that all personnel involved must discuss the day's work in a morning meeting to ensure that it will progress safely and efficiently. It is everyone's responsibility to make sure that the take-off and approach paths are kept clear. External loads must not be flown over people, vehicles or buildings (Taylor pers. comm.).

7.3 Heliportable Lease and Staging Area Preparation

The time frame for preparation of a heliportable lease can be expected to be somewhat longer than a conventional road accessed lease due to limitations on heavy equipment size and the larger required lease size to accommodate additional drilling supplies storage, helicopter loading area, and helipads (including alternate landing area). Some additional time may be required for preparation of a staging area. This additional time will likely still be considerably less than the time required to construct a conventional lease and its associated access road. While this will vary from site to site it is estimated that a heliportable lease would take perhaps two to four months less than a conventional well site and access road, again primarily related to the elimination of a need to construct and later reclaim the access road.

7.4 Drilling Rig Mobilization and Demobilization

A heliportable rig move may require mobilizing between 50 to 200 loads depending on the rig and helicopter for the rig and tubulars and up to an additional 150 to 200 loads of mud, cement and other supplies (Pare, Crowson pers. comm.). Assuming 10 hour flying days and one load per hour this translates into 5 to 20 days for rig mobilization and up to 15 to 20 days for supplies unless more than one helicopter is used. Another 5 to 20, 10 hour days would be required for demobilization. It should be noted that daylight hours in the north are extended in the summer. Between April and September daylight hours can be expected to range from 12 to 20 hours (see Environmental Report, Section 2.4).

The total time to assemble a 3,400 m rated heliportable rig onsite has been estimated at about five days (Pare pers. comm.). This assembly can be occurring concurrently with movement of drill rig components and supplies, provided they are properly coordinated. It is recommended that one or two 30 to 40 ton cranes be used onsite for rig assembly. Cranes with this capacity can be readily broken down into about three loads for transport by helicopter.

Based on these figures, a total of 250 to 600 hours of heavy-lift helicopter flying time or 25 to 60 days could be required for mobilization and demobilization of the rig and necessary supplies. Time required for conventional road access rig mobilization and demobilization is in the range of 10 days.

Total flying time and thus time for mobilization and demobilization, is directly affected by the distance between the staging area and the heliportable drill site. For example to move 200 loads it was roughly estimated to take approximately 25 to 30 hours of flying time to a hypothetical heliportable lease site located 5 km from a given road accessed staging area, and 65 to 70 hours for a lease site located 20 km from the staging area (McDermid, Peterson pers. comm.). For comparison, conventional truck transported rigs with 3,000 m to 5,000 m capability can take between about 25 to 50 loads and typically be delivered to a typical site within four or five days and assembled in an additional five days.

Recent development of "casing drilling" whereby the hole is drilled with casing instead of drill pipe and then cemented in, has the potential to reduce the need for hauling additional loads of drill pipe (Pare pers. comm.). Casing drilling also increases the depth capacity of 3,400 m rigs to 4,500 m because the rig does not have to pull the drill pipe back out of the well.

7.5 Other Timing Considerations

A number of other activities are required to be incorporated into the planning sequence for a heliportable drilling program, though these can be undertaken concurrently and do not affect the total time required for site preparation or drilling. These items potentially include preparation of detailed drilling, transportation and safety plan (2 months), water well packaging (1 week), helicopter pad licensing (3 to 6 months), preparation of heli-lift cementing equipment (90-days) and preparation of open hole logging equipment (90-days). Additional significant lead time would be required in cases where a heliportable rig was being specifically designed and constructed (8 to 10 months) (Luft pers. comm.).

Time required for road construction and reclamation would also be avoided. At the present time, drilling activities in the MK are often restricted to the winter season in order to allow low impact construction techniques. It has been suggested that this restriction could be lifted such that summer heliportable drilling would be allowed. This could be argued to expand the potential operating season for drilling. However, it must also be recognized that while a winter heliportable drill could be carried out, it is a less optimal time for helicopter operation due to the reduced amount of daylight hours.

The use of "casing drilling" mentioned in Section 7.4 above, which avoids the need to use drill pipe, has also been suggested to have potential to reduce drilling time by perhaps 30% (Pare pers. comm.).

Where rigs have to be brought in from international locations on relatively short notice this can be achieved using large C-130 or Hercules transport aircraft (Crowson pers. comm.). This capability could in theory be used to transport a rig to a remote well site where an airstrip had been constructed.

7.6 Conclusion

Heliportable drilling entails it's own unique set of planning and scheduling requirements. The primary advantages in this regard over conventional drilling programs relate to the potentially reduced time for project approval in sensitive areas (particularly if some initial experience has been gained) and elimination of time required for access road construction and reclamation. Heliportable operations do require additional time for rig mobilization, set up and demobilization due to the need to break the rig up into small packages. Heliportable drilling may allow year round drilling within the MK, though this could be reduced where there are particular concerns regarding wildlife, hunting activities and reduced winter day length for Visual Flight Rules (VFR) flying.

8.0 WELL CONTROL AND SOUR GAS BLOW-OUTS

8.1 Probability of Occurrence

Among the more significant concerns that have been raised in regard to the feasibility and practicality of heliportable drilling, are its potential implications when there is a loss of well control and potential uncontrolled release of sour gas and/or liquids (*e.g.*, saltwater, condensate).

Drilling technology and experience have advanced significantly such that the probability of an uncontrolled release or blow-out is low provided current and appropriate professional standards and practice are followed. In BC, blow-out records over the ten year period from 1992 to 2001 indicate there were three "major incidents" (a blow-out occurred and was uncontrolled) (Table 1). For the 5,030 wells drilled in BC over this same period this represents approximately 0.6 blow-outs/1000 wells drilled. Of the "major incidents", the drilling rig was destroyed in two cases, and a relief well was used in one case to intercept and kill the well. In Alberta, between 1991 and 2001, there were approximately 26 blow-outs where there was a release of gas or liquids during the drilling of approximately 89,463 wells (Table 2). This represents approximately 0.3 blow-outs/1,000 wells drilled. The most frequent cause of blow-outs is human error. Columbia Helicopters reports that there have never been blow-outs at any of the 150+ heliportable wells they have worked on (Peterson pers. comm.).

TABLE 2

DRILLING BLOW-OUTS IN ALBERTA AND BRITISH COLUMBIA 1992-2001

	Alberta			British Columbia		
Year	**Wells Drilled[1]**	**Blow-outs[2]**	**Blow-outs/1000 wells**	**Wells Drilled[1]**	**Blow-outs[3]**	**Blow-outs/1000 wells[4]**
1992	3,704	1	0.3	158		
1993	6,807	2	0.3	280	1s	
1994	8,845	3	0.3	490	1m,1s	2.0
1995	8,379	2	0.2	405		
1996	9,489	1	0.1	404		
1997	11,848	1	0.1	460		
1998	7,280	5	0.7	589		
1999	7,698	3	0.4	579	2m,1s	3.4
2000	11,990	6	0.5	593	1	
2001	13,423	2	0.1	834		
Total	**89,463**	**26**	**0.3**	**5,030**	**3m**	**0.6**

1. Canadian Association of Oil Well Drilling Contractors 2002. Does not include servicing rigs activity but does include dry holes.
2. Alberta Energy and Utilities Board 2002. Table enumerates blow-outs during drilling only and does not include blow-outs for active or suspended wells.
3. Krezanoski pers. comm., BC Oil and Gas Commission, 2002. m = major incident involving uncontrolled blow-out, s= significant incident but well brought under control.
4. Based on "major" incidents only.

8.2 Blow-out Prevention and Risk Minimization

Reducing the probability of a blow-out requires proper planning, equipment, mud specification, monitoring and supervision. Ongoing efforts to further reduce the probability and consequence of blow-outs are being pursued on both a company and industry wide basis. The Canadian Petroleum Safety Council (CPSC) has for example recently released its *Industry Recommended Practice* for critical sour drilling (CPSC 2002) to address all aspects of sour drilling in order to ensure worker safety and minimize potential for blow-outs.

Equipment which can be employed to reduce the probability and consequence of a blow-out include: using Class C blow-out prevention equipment (BC Ministry of Energy, Mines and Petroleum Resources 1995) and testing procedures, providing extra high volume mixing tanks (*e.g.*, 400 bbl); using extra high capacity separator and mud weighting capability, using and maintaining high quality tubulars, maintaining a backup companion flange and BOP (single or multiple gate) on site and possibly an additional centrifical separator. All of these equipment items are transportable by helicopter.

In addition to having properly trained and experienced crews, following good basic drilling practices in conjunction with sound contingency plans can further reduce the risk of blow-out. Key examples of these practices include the following:

1. Two drilling foreman should be on location at all times. These supervisors will be scheduled on a 12-hour basis.
2. Pressure integrity testing should be conducted after drilling out the surface casing shoe.
3. The formation should be tested to Leak–Off Pressure or to MACP (Maximum Allowable Casing Pressure).
4. BOP stack should be pressure tested after nipple up on surface casing and again at regular intervals during the drilling.
5. A test plug should be run on bit trips and the well head and BOP stack pressure tested at intervals not exceeding seven days apart.
6. Each crew under the supervision of the Drilling Foreman and the Tower Push should hold daily BOP drills.

Among the concerns raised by the BC Oil and Gas Commission in its rejection of a recent heliportable drilling application was the concern that "the store of loss circulation materials is depleted before the well is brought fully under control" or that the re-supply of other "equipment and materials" could not be guaranteed due the potential for weather conditions to delay flying. This factor was seen to increase the relative risk of heliportable drilling over conventional road accessed drilling. Based on interviews with helicopter operators in the area, no-fly conditions as may occur in the MK would be expected to be short term, and limit transportation capability for portions of any given day as opposed to prolonged, multi-day suspension (Environmental Report, Section 2.3). Given this circumstance it appears that restocking or resupply of equipment could still occur on a daily basis. Helicopters are already relied on to some extent for resupply of equipment where particularly fast turn around is required. The risks mentioned can be further significantly reduced by ensuring a reserve of critical materials are initially stockpiled at the well site (*e.g.*, 50% reserve).

Consulting with a blow-out control company to ensure the site is optimally selected and designed for blow-out control would also help ensure that in the event of a blow-out the well can be efficiently brought under control and collateral environmental damage minimized (Miller pers. comm.). Additional measures include ensuring the last casing set before entering the critical zone is pressure rated to exceed anticipated pressure within the critical zone (Cole pers. comm.). The well site should also be selected such that it can be readily expanded to perhaps twice it's size to provide greater operational flexibility should a blow-out occur.

Where sour gas is potentially present, the drilling camp should be located in a favorable wind and air drainage position such that any H_2S release is less likely to reach the camp. As a general guide, having the camp at least 1 to 1.6 km away from the drilling site could be considered good practice (Pare, Miller pers. com.). Greater or lesser setbacks may be appropriate depending on the site-specific location (Miller pers. comm.). Consideration should also be given to having one or two alternate air equipped shelters and helicopter pads at each emergency escape route. Emergency flight route alternatives should also be included in pre-planning for helicopter drilling.

Under-balanced drilling (using mud pressures below anticipated reservoir pressure), currently practiced on conventional gas wells (including sour wells) to enhance formation gas delivery would require additional heliportable equipment (*e.g.*, high pressure vessels) and require a further degree of supervision and monitoring. Underbalanced drilling has become common and been argued by some to actually safer than overbalanced drilling (Hennegan and Divine 2002) in part due to the higher levels of supervision associated with this activity. Consideration should be given to the relative risk imposed by this drilling technique on any heliportable application.

8.3 Blow-out Response

Where measures to control the release of sour gas (or sweet gas) from an exploration well have failed and there is an uncontrolled blow-out, the operator immediately implements a site-specific Emergency Response Plan and begins procedures for bringing the well under control. These procedures typically involve the following:

- immediate evacuation of personnel on foot via a designated escape route out of the immediate hazard zone;

- potential rig ignition depending on circumstance (*e.g.*, source and type of released product, risk to life);
- contract blow-out control service;
- immediately construct any required additional site drainage and containment to handle released liquids;
- remove equipment and rig from hole (can take two or more days);
- expose and cut off casing and any pipe with magnesium lance or water jet;
- slide new companion flange and valve over well;
- shut-off gas/liquids flow;
- clean-up and/or treat any released liquids contamination; and
- bring in new rig (in most cases sour gas well blow-outs result in rig loss).

In cases where there is good access to the ground around the well site (*i.e.*, not in a muskeg or other very high water area) blow-outs are most typically and effectively controlled by the methods described above rather than bringing in a relief rig (Miller pers. comm.). Relief rigs are now primarily used for rare situations where the casing cannot be accessed reasonably by excavation, in the offshore environment or other situations where heavy equipment access to the well head cannot be achieved (*e.g.*, in cases where the site is underwater *e.g.*, offshore drilling. The time to bring a well under control varies depending on many factors with time ranging from hours to a week or more (most within three weeks), though in virtually all cases, well control is achieved before any relief wells are ever completed.

In cases where a substantial release of gas is involved, it is generally easier and safer to work on a rig which has been ignited (Miller pers. comm.). However, in cases of small releases, well control can often be achieved in an hour or two using air equipment (H_2S protective breathing equipment) without igniting the rig and without exposure of rig crews to unnecessary risk.

Once the valve has been installed and the well capped or partial control gained (*e.g.*, where flow can be directed), there is an opportunity and time to either bring in another heliportable rig or build an access road to deliver a conventional rig. At this point, it may be feasible to use a smaller rig than used on the initial drill assuming the intermediate casing had been set prior to the blow-out. This option may increase the pool of heliportable rigs available to complete the well.

During an actual sour gas blow-out or uncontrolled release on a conventional drilling project, the access roads primary purpose is for delivery of additional well control supplies (*e.g.*, flanges, valves and heavy equipment such as large excavators and bulldozers) and to bring in heavy equipment. This heavy equipment is used to pull key equipment away from the hazard area, to pull the rig off well, to excavate around the well bore to expose the casing, and other earthwork (*e.g.*, ditching and diking to manage liquids release). Concern over potential weather-related unreliability of helicopters for delivery of emergency equipment and supplies once a blow out occurs was among the reasons the OGC rejected the one application for heliportable drilling it has dealt with. As discussed above, the potential for weather delays for heliportable transport are by and large limited to portions of a given day such that such equipment could still be mobilized on any given day. Longer delays (*e.g.*, 2-3+ days) could occur where heavy equipment must be mobilized using heavy-lift helicopter which had to be positioned from a remote location unless this equipment was already stocked on site. In a heliportable application, the most precautionary approach would be to ensure necessary blow-out control equipment (*e.g.*, companion flange and valve assemblies) and basic heavy equipment (*e.g.*, one or two 30 to 40 ton cranes, one D6 or equivalent bulldozer and possibly a larger backhoe such as a CAT 330) are onsite or at least available and transportable on very short notice. Proper site design would also be a risk reducing factor (see 8.3.2 below)

8.3.1 Site Evacuation

Emergency Response Plans usually identify primary and alternate escape routes from the site to a predetermined upwind station. While the access road for a conventional well may also be used for emergency evacuation, this is dependent on the direction of the prevailing wind at the time of the evacuation and is not relied on for initial site evacuation. Alternate routes are seldom cleared or prepared but do provide for a temporary foot access away from the hazard zone. In a heliportable situation, initial evacuation would also be via foot similar to a conventional drilling site. During a blow-out, the use of vehicles in close proximity to the well is unadvisable due to the risk of accidental ignition of released hydrocarbons. Final site evacuation would be via helicopter and require that the helicopter pad be located beyond the zone at which the helicopter could be damaged by heat or flying debris and which could be safely accessed without risk of exposure to sour gas. Consideration should be given to providing some form of temporary shelter, possibly combined with air equipment and a small helipad at the end point of one or more emergency holding areas unless the camp is clearly away from the potential hazard area.

8.3.2 Management of Released Sour Gas and Liquids

In many cases it may be hours or days after an initial kick before there is an actual release or blow-out of gas or liquids to the surface. In the case of a controlled release of gas to surface via the well bore, liquids (frequently salt water and at times some natural gas liquids) would be diverted to a containment tank and gas directed to a flare stack until the well is brought back under control. In this scenario, there are no special transportation requirements assuming there has been adequate onsite storage of emergency drilling supplies. These would be normally kept onsite as part of routine contingency planning in both a conventional and heliportable drilling program. Well control in such cases is normally achieved through increasing mud weights.

In the event of an uncontrolled release of sour gas where there is a perceived hazard to human life, the rig is ignited to eliminate the sour gas hazard. Igniting the well also facilitates follow-up work on the well to bring it under control. In such cases the well site may eventually be doubled in size to facilitate rig and equipment storage and operations. In cases where there is an uncontrolled release of sour water which cannot be ignited at the well bore, the sour hazard can be controlled by diverting the liquid stream to a centrifical separator and then igniting the gas stream (Miller pers. comm.)

Uncontrolled release of liquids at a heliportable well may or may not result in substantial release of sweet or sour gas, salt water or condensate. During a 1999 UPRI blow-out at Klua Lake located 48.5 km southeast of Fort Nelson, BC, the well produced up to 1,200 to 1,500 m^3/day of water which was trucked off-site for disposal into a water injection well (BC Oil and Gas Commission 1999). While this is an extreme case, it provides an indication of the problems a heliportable drilling program could be required to manage. Up to approximately 20 pieces of heavy equipment were onsite at the Klua blow-out to contain water volumes (ditching and diking) and to move the rig and ancillary equipment off-site. This equipment included D8 sized bulldozers and large excavators/hoes (*e.g.,* CAT 245). Concern over the inability to rapidly mobilize necessary heavy equipment to clean up, contain and ultimately remove any blow out associated spilled liquids was also among the reasons for the OGC's rejection of a recent heliportable drilling application.

A heliportable drill site is handicapped by the size of equipment that can be flown in for the purpose of spill containment, cleanup and recovery. As previously discussed, maximum heliportable bulldozer size is a CAT D6 or equivalent. Relatively large hoes can still be transported in pieces for re-assembly on site. For example, a CAT 330 hoe with a 2.8 cubic yard bucket could be transported in about six loads (car body minus track group 10,000 kg (22,000 lb), track group 2,272 kg (5,000 lb), house 10,000 kg (22,000 lb), counter weight 6,636 kg (14,600 lb), boom 3,636 kg (8,000 lb) and stick 1,091 kg (2,400 lb) (Devries pers. comm.). Contingency planning for a potential massive liquids release at a heliportable well site would likely be best served by ensuring the site is properly laid out and drained, identifying a containment area, keeping a reserve of heavy equipment onsite (*e.g.*, one to two D6 bulldozers and one track hoe) and on call, as required.

An alternate to heliportable access for well control involves construction of an emergency road to the well site, an activity that would entail its own additional environmental costs. However, for relatively remote or difficult sites it is likely that the well would be brought under control prior to a road being constructed and that adequate heavy equipment could be heli-transported to the site. A road still may need to be developed depending on the volumes and fate of any released liquids. The Klua Lake blow-out produced approximately 1.2 million kg and 1.5 million kg per day of water requiring storage or disposal. A Chinook 234 would be capable of hauling approximately 13.6 m^3 of produced water per trip (assuming 1,000 kg/m^3) and would require approximately 137 flights per day to move this volume of fluid. Options for treating such fluids onsite would likely be a first course action.

8.4 Blow-out Control Using Relief Rigs

As discussed in Section 8.3 above, most well blow-outs are more immediately controlled by capping rather than bringing in a relief rig. The primary need for a relief well arises when the well head cannot be accessed by heavy equipment and/or potentially where the blow out originates at significant depth below ground. With a conventional road accessed well site a relief rig with sufficient depth capability can be relatively easily obtained from the large pool of conventional rigs in western Canada. The probability of a blow-out is low enough and the availability of conventional rigs is such that the industry typically does not reserve relief rigs during conventional drilling programs, but instead rely on assumed availability.

In the case of a heliportable drilling program, the requirement for a relief rig can be achieved either by mobilizing any available heliportable rigs with sufficient depth capability or by constructing a new access road into the site and mobilizing a conventional rig. In the case of mobilizing a second heliportable rig, a company could choose to either reserve a second rig and incur associated standby charges or rely on assumed availability. As is apparent from Section 2.1, the number of available heliportable rigs in North America is very limited. Partially offsetting this is the fact that relief well capability potentially can be provided by a shallower depth rated heliportable rig.

Where a decision was made to pioneer a new access road into the heliportable site to bring in a conventional rig, delays, environmental impacts, planning/permitting, consultation requirements and costs would be commensurate with the nature of the location.

8.5 Underbalanced Drilling

Underbalanced drilling involves using mud weights below anticipated reservoir pressure in order to reduce the invasion of particulates into the reservoir, as well as avoid several other problems associated with overbalanced drilling such as adverse clay reactions, phase trapping and precipitation and emulsification all of which can greatly reduce the productivity of oil and gas reservoirs. Underbalanced drilling can reduce drilling time (and thus drilling costs), provide greater rates of penetration, increase bit life, provide rapid indication of productive reservoir zones and the option for dynamic flow testing (Hycal Energy Research Laboratories Ltd. 2002). Underbalanced drilling relies on surface equipment rather than mud weight to achieve well control and has been suggested by some to make well control more easily managed and predictable in part owing to the higher level of supervision associated with these operations (Hannegan and Divine 2002). This drilling approach has been in use for over thirty years and has currently evolved to the point where it is being used on sour gas wells. The realization of its benefits and minimization of potential risks demands a relatively high level of planning and communication (Murphy and Thompson 2002). A more exhaustive consideration of its implications for cumulative risk management in regard to underbalanced heliportable exploration drilling should be considered.

8.6 Conclusion

Based on a relatively coarse review of the available statistics, the risk of a blow-out in BC and Alberta ranges from 0.6 to 0.3 blow-outs/1,000 wells drilled and is most often attributed to human error. The high level of supervision and management routinely associated with sour gas drilling suggests that the probability of this occurrence at sour gas wells is likely much lower. The probability of a blow-out at a heliportable well site in the MK is likely very small given the anticipated high level of planning, staffing, supervision and training of the drilling crew which would be selected for this operation.

The drilling program would of necessity still require a blow-out contingency plan which would include provision for well capping or drilling a relief well and management of a liquids release. In most cases, well control will be achieved by capping and a relief rig is not required. Options for relief well capability for a heliportable operation involve either retaining a second heliportable rig on standby or pre-planning for construction of a conventional road access. A relief rig need not necessarily be rated as the original well, as its primary function is to bring the well under control. In the event a heliportable rig is not available for relief well drilling, an emergency haul road would have to be constructed and require an expedited approvals and planning process.

Conventional road access provides no greater ability to provide for initial short-term emergency site evacuation than a heliportable drilling program, but does provide a somewhat greater ability to provide for movement of crews on and off the site following initial evacuation and drilling rig ignition. The availability of a relief rig will be significantly greater with a conventional accessed drilling rig than a heliportable drilling rig due to the number of conventional rigs available.

As with a conventional drilling program, an essential component to managing the risk and consequences of a blow-out in a heliportable operation is the need for a good safety plan with evacuation procedures and training for onsite personnel.

9.0 24-HOUR EMERGENCY MEDICAL RESPONSE

Concern over the ability to adequately manage worker safety and emergency medical response has been raised in regard to the feasibility of heliportable drilling. The access road to a conventional drilling rig provides 24-hour all-weather access to the site for emergency medical evacuations. In a conventional road access scenario, a seriously injured worker in a remote location still relies primarily on helicopter transport for the most efficient evacuation. In conditions locally unfavorable for helicopter evacuation, the injured worker is either held until such transport is available or transported by vehicle until such time as they can be intercepted by helicopter. It would be very unlikely that a seriously injured worker would be driven the full distance to either Fort St. John or Fort Nelson before being transferred to a helicopter.

During consultations with Columbia Helicopters, 24-hour air service capability had not been a component of any of the over 150 heliportable wells they had been involved with (Peterson pers. comm.). Also of interest in this regard, are reports that Columbia Helicopters has never had a helicopter-related injury in any of their heliportable drilling programs. While accidents can and do happen, risks associated with helicopter operation are minimized through provision of adequately trained personnel, ensuring the helipads and staging areas are of adequate size and dust free, thorough planning and supervision prior to and during equipment mobilization, and by working out defined flight paths and contingency routes in advance. Further reduction of the likelihood of a serious accident during the actual drilling program can be achieved through ensuring that only properly trained and experienced crews are used on any heliportable program. Lack of rig worker experience combined with poorly handled supervision of rig crews has been identified as a significant source of most injury related accidents during drilling programs (Calgary Herald, December 26, 2001).

Scheduling a heliportable operation outside of the winter period when longer day length is available, extends the daytime operating window for helicopter flying. In the event company policy or regulator required 24-hour well site access, helicopters, crews and landing areas would have to be set up for Night Visual Flying Rules (Night VFR) and possibly a full Instrument Landing System (ILS). These systems are available. The more sophisticated ILS, while not essential would cost about $1 million and require approximately 6 months for an approval (Adamson pers. comm.). As discussed in the Environmental Report, icing conditions, can temporarily make conditions inoperable for helicopter transportation. Such conditions tend to be seasonal, relatively infrequent and rarely last more than a few hours during any given day (Adamson pers. comm.). In such cases, an injured worker would have to be treated onsite until conditions improved.

While most heliportable drilling operations are serviced by a single helicopter during the drilling phase, consideration could be given to maintaining a smaller back up machine (*e.g.*, A-Star) in order to further increase emergency response capability. Other options to increase emergency response capability would be the identification and hand clearing of an ATV accessible emergency egress route to the nearest all weather access point though functional achievement of this objective may in some instances defeat the purpose of heliportable access in the first instance.

To be technically feasible, heliportable drilling must either provide for such 24-hour all-weather access and/or ensure that all emergency medical needs can be effectively met onsite and in compliance with Workers' Compensation Board of BC (WCB) regulations. The requirements of the WCB are detailed in Section 10.0 of this report. The WCB does not prohibit high risk work sites where activity is only provided by aircraft (Phillips pers. comm.). Numerous remote logging sites, fishing camps and communities are able to operate in compliance with WCB requirements for first aid without 24-hour access.

The WCB would, as with all industrial activities require a risk assessment and written procedures to deal with the site-specific circumstances and hazards of the project (see Section 9.0). By virtue of the well site having both a medical response facility and potentially a helicopter stationed onsite, a heliportable drilling operation in the MK could be argued to provide a greater level of emergency medical response than a conventional drilling rig, which does not typically have a helicopter onsite.

9.1 Conclusion

There are a number of high risk and/or remote work sites in BC that lack guaranteed 24-hour emergency access that provide emergency medical response capability in compliance with WCB regulations. By following similar practice and having a site-specific risk assessment and response plan, a heliportable drilling program would be in compliance with WCB regulations. While not essential for WCB compliance, individual companies could achieve elevated safety contingency by using 24-hour capable helicopter service, minimal ATV egress trails and/or two helicopters onsite. Seasonally scheduling drilling operations during periods of longer day length provides a longer potential window for emergency medical evacuation under VFR conditions. Risk of worker injury could be significantly reduced on a heliportable drilling program by ensuring only experienced drill crews are used. Emergency planning should also consider monitoring and response needs associated with forest fires in order to ensure worker safety.

10.0 WORKERS' COMPENSATION BOARD OF BC

As part of the heliportable feasibility evaluation, an interview was conducted with the Workers' Compensation Board of BC (WCB) (Phillips pers. comm.). The regulations are specified under the Occupational Health and Safety Regulations (OHS) (WCB 2002), and heliportable drilling would require specific attention and compliance with Regulations in Part 4 (General Conditions), Part 33 (Occupational First Aid), Part 29 (Aircraft Operations) and Part 23 (Oil and Gas). The WCB does not prohibit high risk activities, including oil and gas exploration and development, where access is only by aircraft. The following section provides a summary of the WCB requirements on a heliportable well site.

The proponent must conduct a risk assessment. This is required in any workplace in which a need to evacuate or rescue workers may arise (Regulation 4.13), in addition written procedures for transporting injured workers, including who and how to call for transportation and prearranged routes is also required (Regulation 33.28). As per OHS Regulation 33.37 (air transport), in aircraft dependent operations the designated aircraft can substitute for an emergency transport vehicle (ETV) provided that arrangements have been made for an appropriate aircraft to be available, a list of air frequencies is provided in the written procedures, first aid equipment of the type suitable for an aircraft must be available (*e.g.*, aircraft rated spine boards and stretcher) and if weather or other factors could reasonably delay the use of aircraft, alternative transportation options must be provided where practicable (WCB 2002).

According to Schedule 1, Table 1 (OHS Regulation Part 33), a Level 3 Kit, Dressing Station and ETV equipment and a Level 3 attendant are required onsite if the number of workers per shift is between 11 and 30. If the numbers exceed 30 workers per shift, then a Level 3 Kit, First Aid Room, ETV equipment and a Level 3 attendant are required. Regulation 33.10(g) requires that first aid rooms in remote locations are required to provide room and equipment for overnight care for at least two injured workers. The WCB further suggests that the number of workers per shift reflects the maximum number of people that could potentially be onsite at any one time to ensure compliance with the first aid regulations throughout the scope of the operation (*e.g.*, during completions the number of workers onsite may increase substantially and OHS Regulation 33.18 requires that for remote workplaces with lodgings, the number of workers per shift includes all workers at the camp and well site when calculating first aid coverage requirements). Access to the First Aid Room cannot be impeded at anytime, particularly in the event of an "upset" condition such as blow-out or fire. The most preferred location for the First Aid Room is either adjacent to the well site in a designated safe location, or between the well site and the camp along the short 1 km connector road.

WCB evacuation procedures only specify that workers be readily able to safely leave the defined hazard zone by foot, snowmobiles, snow cat or ATV and that there is an identified escape plan and route (Regulation 33.28). These same provisions apply to conventional drilling programs.

10.1 Conclusion

There appears to be no significant obstacle to the operation of heliportable drilling in compliance with WCB rules and regulations.

11.0 PIPELINE AND FACILITY CONSTRUCTION

For conventional pipeline construction in the MK a typical project would involve clearing and installing a buried pipeline usually within a 15 m to 18 m wide right-of-way. Right-of-ways are typically re-contoured to approximate original contours. Roads constructed to allow access for the original exploration or development wells are usually used as pipeline routes although at times, pipeline routing may be shortened to avoid extreme switchbacks and/or to take advantage of another existing linear disturbance. The ability to use the original access road increases the speed at which a pipeline can be constructed as well as reduce costs for this operation.

In the event of a successful well at a heliportable site, a decision would have to be made as to whether a road would be constructed to the site to allow monitoring and servicing of the well, or whether the site would remain helicopter accessed. In the former case, the road and pipeline would be constructed together. In the latter case, the pipeline would be constructed alone, probably via a shorter route than would have occurred via where it followed a potential access road. Heliportable pipeline stringing and welding has been successfully undertaken in some cases to expedite pipeline construction over sensitive ground conditions (*e.g.*, muskeg) (Hunley pers. comm.). Installation of a non-buried pipeline using helicopters, to a heliportable well site may allow further reduction in the amount of surface area disturbance, though this does introduce a unique set of environmental and pipe integrity factors that would need to be considered.

Other facility components such as line heaters, separators and tanks can be transported via helicopter. Compressor loads can weigh up to 113,636 kg (250,000 lb) and would require significant disassembly and reassembly.

11.1 Conclusion

The potential value of helicopters to practically reduce the impacts of pipeline construction in the MK are limited. The primary option would be to use the helicopter to sling pipe either in individual joints or longer pre-welded lengths to the site rather than requiring the additional surface preparation to allow for movement of pipe trucks in certain locations. The cost of this incremental reduction in surface area disturbance would need to be further evaluated.

12.0 OPERATIONS

Numerous remote wells and valves are accessed by helicopter on a seasonal basis. These wells typically have conventional road access during winter to allow for deployment of service rigs for work-overs or other equipment intensive activities. Some companies in western Canada are specializing in heliportable well servicing where the operator is also the pilot (Hunley pers. comm.). These operators may make daily trips to the facility by small helicopters (*e.g.*, Robinson 22's and 44's) depending on requirements and are used to service remote sour and sweet wells. Even where there is potential road access, this approach can be used to reduce the need and cost for road maintenance and potential upgrade.

12.1 Conclusion

Heliportable well site operation is technically feasible, however, in the absence of seasonal road access, equipment such as heliportable service rigs, frac units and other equipment would have to be disassembled and flown via heavy-lift helicopter to the site. No technical limitations would appear to preclude this. The primary factor involved would be related to incremental costs

13.0 ABANDONMENT

Site abandonment typically involves plugging the wellbore, removal of all surface facilities and follow-up work to replace and recontour graded materials and topsoil, installation of any erosion control measures and seeding. For a conventional road accessed well site, road reclamation would typically follow. For a heliportable well site, all surface facilities would have to be transported offsite by helicopter. Heavy equipment for necessary earthwork would have to be remobilized by helicopter.

Conclusion

There are no apparent technical limitations to site abandonment using helicopters.

14.0 RECOMMENDATIONS

1. A set of best practices should be developed which would focus on needs for overall heliportable planning and coordination, training requirements, supervision, environmental protection, blow-out prevention and response.
2. The influence of underbalanced drilling on blow-out risk should be further evaluated.
3. The potential applicability of emerging technology such as "casing drilling" to significantly extend the depth range and possible safety of heliportable rigs should be further monitored and explored.
4. Consideration should be given to collaboratively undertaking these initiatives through the Canadian Petroleum Safety Council or equivalent provincial body.

15.0 REFERENCES

15.1 Personal Communications

Adamson, Murray. Canadian Helicopters. Fort St. John, British Columbia.

Atwell, Dale. Helmerich and Payne Drilling Inc., Tulsa, Oklahoma

Braden, J. Haliburton Energy Services. Houston, Texas.

Cole, Orville. Fire Creek Resources. Calgary, Alberta.

Clark, G. ATCO Structures. Calgary, Alberta.

Crowson, Randy. Parker Drilling. Houston, Texas.

Devries, D. Finning Canada. Calgary, Alberta.

Hunley, Tony. Airborne Energy Solutions. Calgary, Alberta.

Krezanoski, Dave. BC Oil and Gas Commission. Fort. St. John, British Columbia.

Luft, Barry. Fire Creek Resources Ltd. Calgary, Alberta.

Matheson, Andre. Reeves Wireline. Calgary, Alberta.

McDermid, Gary. Helifor Industries Limited. Vancouver, British Columbia.

Miller, Mike. Safety Boss. Calgary, Alberta.

Pare, Treena. Drillers Technology Corp. Calgary, Alberta.

Peterson, Todd. Columbia Helicopters. Portland, Oregon.

Phillips, B. Workers' Compensation Board of BC. Fort St. John, British Columbia.

Taylor, Corey. Vancouver Island Helicopters. Fort St. John, British, Columbia.

Thatcher, D. Sanjel Corporation. Calgary, Alberta.

Sroka, G. Access Waterwells Inc. Edson, Alberta.

Wolford, Simon. Anderson Waterwells. Fort St. John, British, Columbia.

Ziebell, Trevor. Murphy Oil Company Ltd. Calgary, Alberta.

15.2 Literature Cited

Alberta Energy and Utilities Board. 2002. Spill Release Report for 1992 to 2001.

BC Ministry of Energy, Mines and Petroleum Resources. 1995. British Columbia Oil and Gas Handbook. November 1995.

BC Oil and Gas Commission. 1999. Information Release - December 13, 1999. Union Pacific Resources Inc. Search Klua d-27-J/94-J-8. Uncontrolled Gas Release.

BC Oil and Gas Commission. 2002. Well Incidents.

Calgary Herald. 2001. Rig Accidents on the increase stats show: Green workers, more activity blamed for rise. December 26, 2001. Pg. D2.

Canadian Association of Oil Well Drilling Contractors. 2002. Electronic Data Base.

Canadian Petroleum Safety Council. 2002. Industry recommended Practice (IRP) Volume 1 Critical Sour Drilling. Canadian Petroleum Safety Council., Calgary, Alberta.

Journal of Petroleum Technology. 2001. Casing drilling: An emerging technology. Journal of Petroleum Technology Online. June 2001. http://www.spe.org/spe/cda/views/jpt/jptMaster/0,1513,1648_2300_6269_7,00.html

Hannegan, D. and R. Divine. 2002. Underbalanced drilling-perceptions and realities of today's technology in offshore applications. Weatherford International Inc. IADC/SPE Drilling Conference. Dallas, Texas, 26-28 February, 2002.

Hycal Energy Research Ltd. 2002. Underbalanced drilling, praises and perils. No. SPE 35242. http://www.hycal.com/papers/papers22.htm.

Murphy, R.D. and P.B. Thompson. 2002. A drilling contractor's view of underbalanced drilling. IADC/SPE Drilling Conference. Dallas, Texas. 26-28 February, 2002.

Oil and Gas International. 2002. Conoco, Tesco unveil groundbreaking way to break ground. 2/12/2002-OGI 24/7. http://www.oilandgasinternational.com/departments/drilling_completion/feb02_conoco.html.

Workers' Compensation Board of BC. 2002. Occupational Health and Safety Regulations. http://regulation.healthandsafetycenter.com/s/Home.asp

APPENDIX A

TYPE AND AVAILABILITY OF HELIPORTABLE RIGS

Company	Heliportable Drilling Rig	Maximum Drilling Depth (m)	Cost/day (CND)	Current Location	Number of Loads
Drillers Technology Corp., Calgary, Alberta	Rig No.4, 5,6, 7	3,400	12,000 - 14,000	Canada	50 (~36 for rig, 14 for tubulars)
Parker Drilling, Houston, Texas	115, 131, 140, 145, 160, 190, 223	5,486	26,000 - 30,000	Peru, New Guinea, Indonesia, Columbia	150 - 200
	146, 206, 225, 226, 250	~6,400	~30,000	Indonesia, Peru	150 - 200
	188	>6,400	33,000	New Zealand	150 - 200
	228, 255	6,705	33,000	Peru, Bolivia	150 - 200
Helmerich and Payne Drilling, Tulsa, Oklahoma	Rig 170	9,144	35,000 (approx.)	South America	180 using a Chinook 234
	Ideco #22	5,486	N/A	South America	
	Ideco #23	5,486	N/A	South America	

APPENDIX B

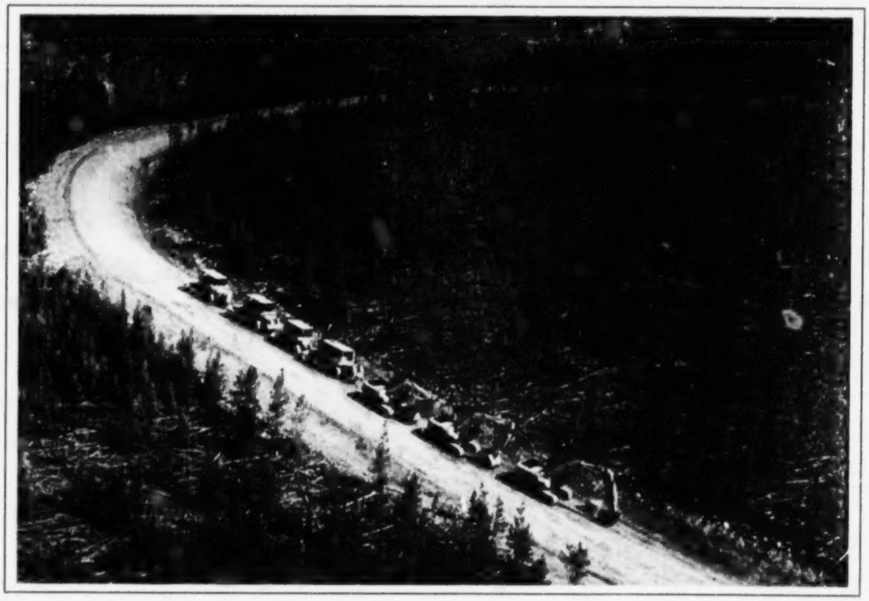
CAPABILITY AND AVAILABILITY OF HEAVY AND MEDIUM LIFT HELICOPTERS IN NORTH AMERICA

	Name	Working Weight for Loads	Hourly Rate * (CND, fuel not included)	Fuel Consumption (L/hr)
Heavy Lift Helicopter	Boeing Chinook 234	10,886 kg (24,000 lb)	$13,500 -$14,500	1,530
	Boeing Vertol 107 (II)	4,080 kg (9,000 lb)	$4,700 - $5,200	630
	Sikorsky S-64	E Model: 7,700 kg (17,000 lb) F Model: 9,525 kg (21,000)	$10,000 - $12,000	1,985
	Sikorsky S-61A	3,625 kg (8,000 lb)	$4,500 to $5,000	640
	Sikorsky S-61L	3,175 kg (7,000 lb)	$4,500 to $5,000	1.050
	Kamov Ka32A11BC	4,535 kg (10,000 lb)	$5,500	N/A
	Super Puma	8,000 lb	$5,000 to 5,500	1,050
Medium Lift Helicopter	Bell 212	1,270 kg (2,800 lb)	$2,525 (1 pilot) $4,000 (2 pilots for 24-hour operation)	375

* All rates are approximate and vary between operators

MUSKWA-KECHIKA MANAGEMENT AREA HELIPORTABLE DRILLING STUDY

ECONOMIC REPORT



Prepared for:

BC Ministry of Sustainable
Resource Management,
Muskwa-Kechika
Advisory Board
and the
BC Oil and Gas Commission

Prepared by:

Randal Glaholt and Lois Pittaway

TERA Environmental Consultants
Suite 1100, 815 - 8th Avenue S.W.
Calgary, Alberta T2P 3P2

Brian Churchill

Chillborne Environmental Services
SS2 Site 22 Comp 23
Fort St. John, BC V1J 4M7

Harris Wheeler
AAEA Ltd.
Charlie Lake, BC V0C 1H0

June 2002
2555

EXECUTIVE SUMMARY

Previous heliportable feasibility evaluations, while recognizing the potential environmental advantages of heliportable drilling, have frequently identified the direct incremental cost of heliportable drilling as a key factor limiting the feasibility of heliportable drilling. The Economic Report identifies and explores a number of key cost factors associated with conventional versus heliportable drilling and draws on previous heliportable cost analyses conducted in northeastern BC. The major cost differences identified were associated with access. While total road costs and helicopter costs tend to go up with increasing distance, road related costs are much more variable due to specific terrain differences, reclamation challenges from site to site and the potential significant influence of short-term and seasonal weather patterns. For heliportable drilling there is a relatively linear relationship between distance and cost. The influence of weather on heliportable transport cost is projected to be very minor.

Depending on the site conditions, heliportable drilling appears to have greater potential to be more expensive than conventional road access for programs requiring relatively short access but less expensive, considering direct costs alone relative to longer more complex roads through sensitive terrain. The primary costs associated with heliportable drilling include those associated with potential foreign rig mobilization, rig mobilization from the staging area, helicopter support during drilling, contingency stockpiling and potentially water supply.

Heliportable rigs, like conventional rigs, range in cost depending on their drilling depth capability. Mobilizing a medium to large heliportable local rig may cost in the vicinity of $500,000 while mobilizing the same rig from a foreign location to northeastern BC could be in the range of $1.5 million to about $2.5 million CDN. At the time of this review, there were four heliportable rigs in North America all depth rated to 3,400 m.

A conventional drilling rig can be converted to a heliportable rig. Depending on the size of the drilling rig, the cost of this conversion would likely range from $2 million to $5 million CDN and take perhaps 4 to 6 months. Rough cost estimates to custom build a heliportable rig were variable and dependent on rig size and whether the rig was built in Canada or the US. These rough estimates ranged from $12 million CDN to $20 million US. Costs to build a heliportable rig capable of drilling to 3,400 m were estimated at $6 million to $7 million CDN. Construction time to build a deep-rated heliportable rig was estimated to take approximately 8 to 10 months.

While redesigning a conventional rig appears to be more cost effective than building a new heliportable rig, this approach is disfavored by the drilling contractors as it requires taking a conventional rig out of normal service and has potential to result in a less purpose-built design integrity. Although the risk of a blow-out is very low, in the event a relief rig is required, this can be achieved either by mobilizing any available heliportable rigs with sufficient rig depth capability or by constructing a new access road to the site and mobilizing a conventional rig.

Substantial additional costs can be expected in either case. Costs associated with any requirement to guarantee a designated relief well throughout the drilling program would result in a further substantial cost that would have implications for overall cost and projected returns on investment.

If company policy or regulators required 24-hour well site access, helicopters, crews and landing areas would have to be set up for Night Visual Flying Rules and possibly a full Instrument Landing System. A 24-hour, on demand, helicopter serviced operation would require additional items and costs and add perhaps close to $1 million to the cost of a 90-day heliportable drilling program. Substantial additional costs can be expected in either case.

Weather delays encountered during either a conventional or heliportable operation can be expected to increase costs by incurring standby charges and/or by delaying completion of critical phases of the project. Weather delays associated with a conventional road accessed well site can occur in the summer as a result of rain, as a result of delays in freeze-up and early spring thaw. Weather delays associated with a heliportable well site can occur as a result of low cloud cover/fog, icing and high winds.

Blow-outs result in significantly increased costs for both conventional and heliportable exploration drilling programs. For a heliportable well site, the monetary costs can be expected to be substantially greater than with a conventional blow-out due to the potential need to bring in additional heavy equipment and other blow-out containment supplies by helicopter. This cost can be substantially reduced by proper contingency planning and retention of some heavy equipment onsite.

A primary difference between conventional road accessed drilling and heliportable drilling is that the heliportable option does not require reclamation beyond the well site, camp and staging area. While impacts and reclamation costs can be significantly reduced with low impact winter roads, opportunities to carry out this practice in the MK are very site-specific. In general, road reclamation costs are expected to be roughly equivalent to road construction costs.

Site-specific and judicious promotion of heliportable drilling within the MK has potential to result in sustainable long-term economic benefit and employment with a reduction in environmental and related social costs. Integration of heliportable technology into the petroleum industry in northeastern BC may potentially diversify and strengthen the base for local contracting and joint ventures.

It is recommended that: a clear policy be developed with regard to the use of heliportable drilling in the MK to reduce uncertainty within the industry and among resource users; heliportable guidelines are identified prior to a land posting and are location specific; consideration be given to offering financial incentives to the petroleum industry where commitments are made to use heliportable drilling.

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY i

1.0 INTRODUCTION 1

2.0 PREVIOUS HELIPORTABLE VS. CONVENTIONAL COST COMPARISONS CONDUCTED IN NORTHEASTERN BC 2

3.0 GENERIC CASE STUDY COMPARISON OF PROBABLE HELIPORTABLE VS. CONVENTIONAL COSTS FOR THE MUSKWA-KECHIKA 8

4.0 COST OF HELIPORTABLE DRILLING RIGS 10
- 4.1 Conversion of Conventional Rigs and Custom Designed Heliportable Rigs 10
- 4.2 Relief Drilling Rig and Blow-out Control Costs 12

5.0 HELICOPTER RATES 13
- 5.1 Helicopter Planning and Logistics 14
- 5.2 24-Hour Operation 14

6.0 OTHER HELIPORTABLE DRILLING COST CONSIDERATIONS 15
- 6.1 Stockpiling 15
- 6.2 Rig and Camp Water 15
- 6.3 Casing Drilling 15
- 6.4 First Aid Requirements 16
- 6.5 Insurance 16

7.0 POTENTIAL COSTS RELATED TO WEATHER DELAYS, SEASONAL CONDITIONS AND BLOW-OUTS 17
- 7.1 Weather Delays and Seasonal Conditions 17

8.0 RECLAMATION COST CONSIDERATIONS 18

9.0 INVESTMENT OPPORTUNITIES, JOB CREATION AND GOVERNMENT REVENUE 19

10.0 CONCLUSION 22

11.0 RECOMMENDATIONS 23

12.0 REFERENCES 24
- 12.1 Personal Communications 24
- 12.2 Literature Cited 24

LIST OF APPENDICES

Appendix A Cost Analysis from Previous Projects 26

LIST OF FIGURES

Figure 1 Cost Factors Influencing Heliportable Economic Feasibility 1

Figure 2A Comparison of Road-Based Drilling and Helicopter-Based Drilling Cost Estimates for Various Exploration Drilling Projects in Mountainous Areas of Northeastern BC ..... **Error! Bookmark not defined.**

Figure 2B Comparison of Road Construction and Helicopter Transportation Cost Estimates for Various Exploration Drilling Projects in Mountainous Areas of Northeastern BC ..... **Error! Bookmark not defined.**

LIST OF TABLES

Table 1 Conventional vs. Heliportable Cost Comparisons from Previous Projects in Northeastern BC 3
Table 2 Generic Conventional vs. Heliportable Cost Comparison Scenarios 9
Table 3 2002 Heliportable Drilling Rig Rates and Mobilization Fees 11
Table 4 Helicopter Rates 13
Table 5 Potential Economic Costs and Benefits of Heliportable Drilling in the MK 20

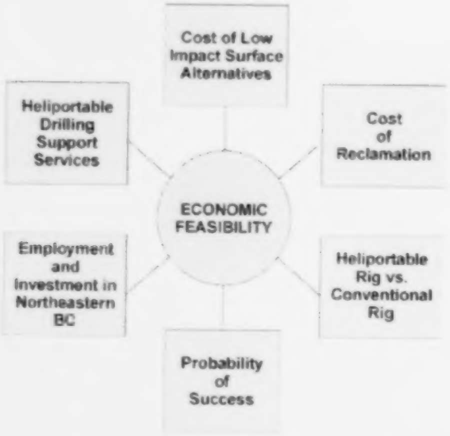
1.0 INTRODUCTION

Previous heliportable feasibility evaluations, while recognizing the potential environmental advantages of heliportable drilling, have frequently identified the incremental cost of heliportable drilling as a key factor limiting the feasibility of heliportable drilling. Industry interviews conducted for the present study reconfirmed the belief that heliportable drilling was likely to be more expensive than conventional surface access.

The following report provides information on the detailed cost implications of technically feasible and environmentally sound helicopter supported drilling operations. The report identifies and explores a number of key cost factors associated with conventional versus heliportable drilling (Figure 1) and draws on previous heliportable cost analyses conducted in northeastern BC, industry experience with road construction costs in the area and industry experience with heliportable drilling in other locations. Using this data, cost comparisons for two hypothetical locations are presented. These hypothetical locations are a well site requiring 5 km of new access over gentle terrain (Scenario 1), and a site located in more mountainous terrain and requiring approximately 20 km of new access (Scenario 2). The resources and time provided for this study are insufficient to do a full cost benefit analysis in regard to their full economic implications or to exhaustively model the economics of heliportable operations, however, an attempt has been made to highlight what are felt the more relevant considerations and differences.

The implications of helicopter supported drilling on investment opportunities, job creation and government revenues are also discussed.

Figure 1 **Cost Factors Influencing Heliportable Economic Feasibility**


Cost of Low Impact Surface Alternatives
Heliportable Drilling Support Services
Cost of Reclamation
ECONOMIC FEASIBILITY
Employment and Investment in Northeastern BC
Heliportable Rig vs. Conventional Rig
Probability of Success

2.0 PREVIOUS HELIPORTABLE VS. CONVENTIONAL COST COMPARISONS CONDUCTED IN NORTHEASTERN BC

The cost of conventional road accessed drilling and heliportable drilling in mountainous portions of northeastern BC has been examined in varying detail by three companies:

- Imperial Oil Limited (IOL)(a-53-K/93-I-8) Belcourt Creek, 1995;
- Murphy Oil Company Ltd. (Murphy) (b-33-B/94-G-6) Sikanni 1996; and
- Marathon Canada Ltd. (Marathon), (d-40-J/94-G-3) Koller Creek, 2001.

From IOL's detailed cost breakdown, the largest cost differences between the two alternatives were attributable to (in descending order):

Higher Heliportable Costs

1. Material supply and haulage
2. Contingency (25%)
3. Daily fixed operating costs
4. Pre-spud and post-release costs (Rig Mobilization, Demobilization)
5. Third party contractor charges
6. Supervision and administration

Higher Conventional Costs

1. Road construction
2. Road maintenance

For the IOL estimates, the increments associated with daily fixed operating costs were associated with the assumption that due to limitations in heliportable rig availability, IOL would have to assume a less competitive day rate for the drilling rig (this amounted to an incremental $7,000/day or $1.1 million for the program). The pre-spud and post-spud increment (approximately $1 million) was associated with foreign rig mobilization charges. IOL concluded that heliportable drilling would add approximately $5.7 million to the exploration program and stated overall that it could increase costs between 50% and 100% of the original costs. The 25% contingency applied to IOL's heliportable operation accounts for a substantial increment owing to their uncertainty around heliportable operations. Also of note is the fact that IOL's comparison seemingly did not account for road reclamation costs and could have increased the actual construction and drilling costs by about 37% and reduced the heliportable premium to about 17% or near equivalency if the 25% heliportable contingency was reduced (IOL 1995).

In the Murphy analyses, the largest increments contributing to differences between heliportable operations and conventional road accessed drilling were attributable to (in descending order):

Higher Heliportable Costs

1. Rig-up, drill, rig down
2. Rig mobilization and demobilization
3. Drill water well/set conductor

Higher Conventional Costs

1. Road construction
2. Reclamation
3. Road maintenance

Murphy's heliportable option was approximately 16% more expensive than the conventional road access.

Marathon's heliportable analysis was conducted by Fire Creek Resources Ltd. (2001a), and the largest cost increments for heliportable drilling were associated with rig mobilization and demobilization from the staging area (approximately $1.8 million, including supplies) and daily helicopter support with an IFR Bell 212 (approximately $1.1 million). The total cost of helicopter transportation was estimated at $3.2 million and represented a 24% ($1.7 million) increase over their estimates for conventional access

While drilling rig positioning and daily charge-out rates can be significant, direct costs associated with access, whether by road or helicopter, account for the major differences between these alternatives. A summary of access related costs for IOL, Murphy and the recent Marathon (Koller Creek) well are presented in Table 1 and additional detail is provided in Appendix A.

TABLE 1

CONVENTIONAL VS. HELIPORTABLE COST COMPARISONS FROM PREVIOUS PROJECTS IN NORTHEASTERN BC

		Marathon Canada Ltd. **c-40-J/94-G-3(2000)**	**Murphy Oil Company Ltd.** **c-32-B/94-G-6 (1996)**	**Imperial Oil Ltd.** **Belcourt** **a-53-K/93-I-8 (1995)**
CONVENTIONAL	Length of Road (km)	3.6 km (new access)	2 km	24.5
	Road Construction	$1,000,000	$1,030,000 (new road)	$3,474,800
	Road Reclamation	$500,000	$1,000,000	$3,474,800 (assumed equal to construction)
	Total Road Cost	$1,500,000	$2,030,000	$6,949,600
	Cost per km (construction and reclamation)	$416,666/km	$1,015,000/km	$283,657/km
	Total Conventional Drilling Program	$7,000,000	$7,000,000	$9,300,000 (did not include incremental cost of reclamation above)
	Total Conventional Drilling Program Cost/km	$1,944,444	$3,000,000	$379,592
HELIPORTABLE	Helicopter Cost	$3,155,000	$2,700,000	$5,700,000
	Helicopter Costs/km	$876,388	$1,350,000	$232,653
	Total Heliportable Drilling Program Estimate	$8,655,000 (conventional -road + helicopter)	$8,400,000	15,000,000 (included foreign rig mobilization)
	Total Heliportable Drilling Cost/km	$2,404,166	$4,200,000	$612,245

Sources: Patterson pers. comm., Murphy 1996, IOL 1995

On a per km basis, estimates for road construction and reclamation between these three projects averaged approximately $572,885/km. Another operator in the area, Husky Energy Inc. (Husky) uses a figure of approximately $200,000/km for construction cost estimates in mountainous areas and $100,000/km in foothills areas (Pow pers. comm.). Similar road construction cost estimates are used by Talisman Energy for mountain road construction. These costs amount to $400,000/km and $200,000/km respectively when equivalent costs for reclamation are factored in. Some companies estimate reclamation costs at approximately 2/3 of construction costs though this will be dependent on many factors (Staniland pers. comm.). On more difficult terrain in mountainous portions of northeastern BC, construction costs have exceeded $350,000/km to $400,000/km for construction alone or $700,000/km to $800,000/km for construction and reclamation (Staniland pers. comm., Pow pers. comm.). These latter costs were associated with construction of full grade roads built to multi-season forestry road standards. In settings where lower grade roads can be constructed, these costs can be reduced by perhaps half in some cases. It is worth noting that in some instances, low impact winter road construction can result in significant cost savings compared with conventional road construction. For example, the recent low impact winter road developed by Murphy for its two wells at Chicken Creek was estimated to cost approximately $187,000/km. Using the same heliportable estimate as used by Murphy on its nearby b-33-B/94-G-6 well would suggest that a heliportable drilling program at Chicken Creek would have paid an approximate $1,163,000/road-km premium had they been required to heliportable drill.

The relatively short Marathon and Murphy access roads were approximately 2.1 to 1.3 times cheaper per kilometer respectively than the estimated helicopter cost/road-km of conventional access. These differences represented a hypothetical $456,388/km premium for heliportable mobilization, support and demobilization on Marathon's well (d-40-J/94-G-3) and $335,000/km for Murphy's well (b-33-B/94-G-6). Based on figures provided by IOL, the per km cost for conventional road construction ($283,657/km) on their relatively long access, was 1.2 times as expensive as was the heliportable alternative ($232,653/km), assuming the cost of road reclamation is included in the overall road cost. As mentioned above, IOL's estimate for heliportable costs included a 25% contingency, as well as an additional $1 million to mobilize a suitable rig from Wyoming.

While direct total road costs and helicopter costs tend to go up with increasing distance, road costs are much more variable due to specific terrain differences and reclamation challenges from site to site. For heliportable drilling there is a relatively linear relationship between distance and cost. Weather has some potential to delay heliportable rig mobilization, however, this potential is arguably very limited and amounting to portions of individual days. Where conventional road access is developed, factors such as unexpected terrain instabilities, early break-up, delays in freeze-up, and unseasonably wet weather can all have unpredictable and potentially profound effects on construction costs and the overall drilling schedule. The risk of this occurring also tends to be greater in mountainous areas, particularly where long access roads are required.

Previous exploration programs in these settings in northeastern BC have resulted in road construction costs in some cases doubling or tripling from initial estimates. A range of cost/km estimates and actual costs for recent conventional and heliportable drilling are graphically presented in Figure 2A, and for transportation in Figure 2B, along with two hypothetical MK scenarios (see Section 3.0).

On longer roads, combined construction and reclamation costs can be expected to eventually exceed direct costs for heliportable operations assuming the heliportable well site has been adequately stocked and the daily servicing requirements are being conducted by a medium lift helicopter. This ignores further indirect cost factors in favor of heliportable drilling resulting from reduced environmental degradation.

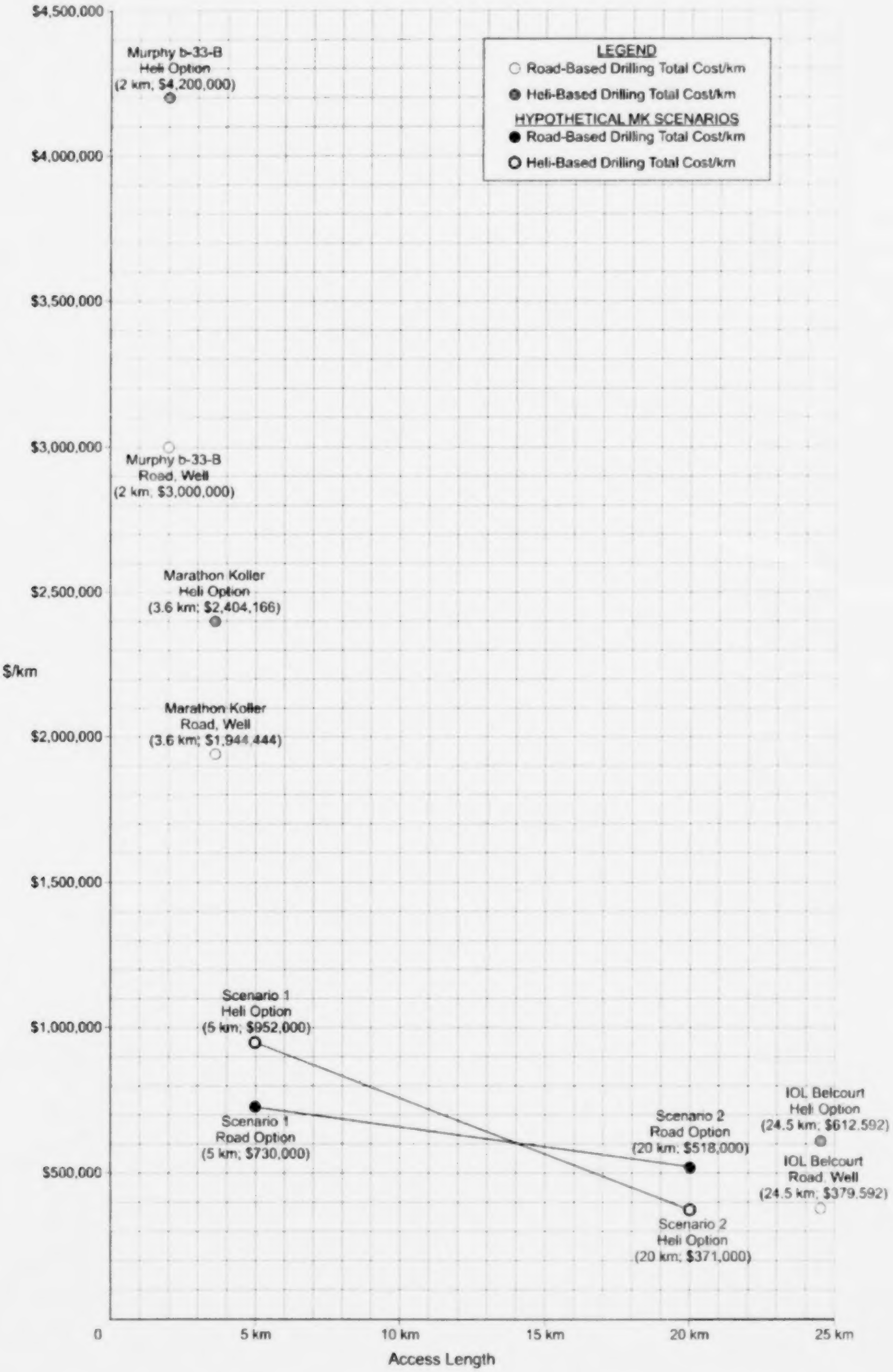


FIGURE 2A COMPARISON OF ROAD-BASED DRILLING AND HELICOPTER-BASED DRILLING COST ESTIMATES FOR VARIOUS EXPLORATION DRILLING PROJECTS IN MOUNTAINOUS AREAS OF NORTHEASTERN BC

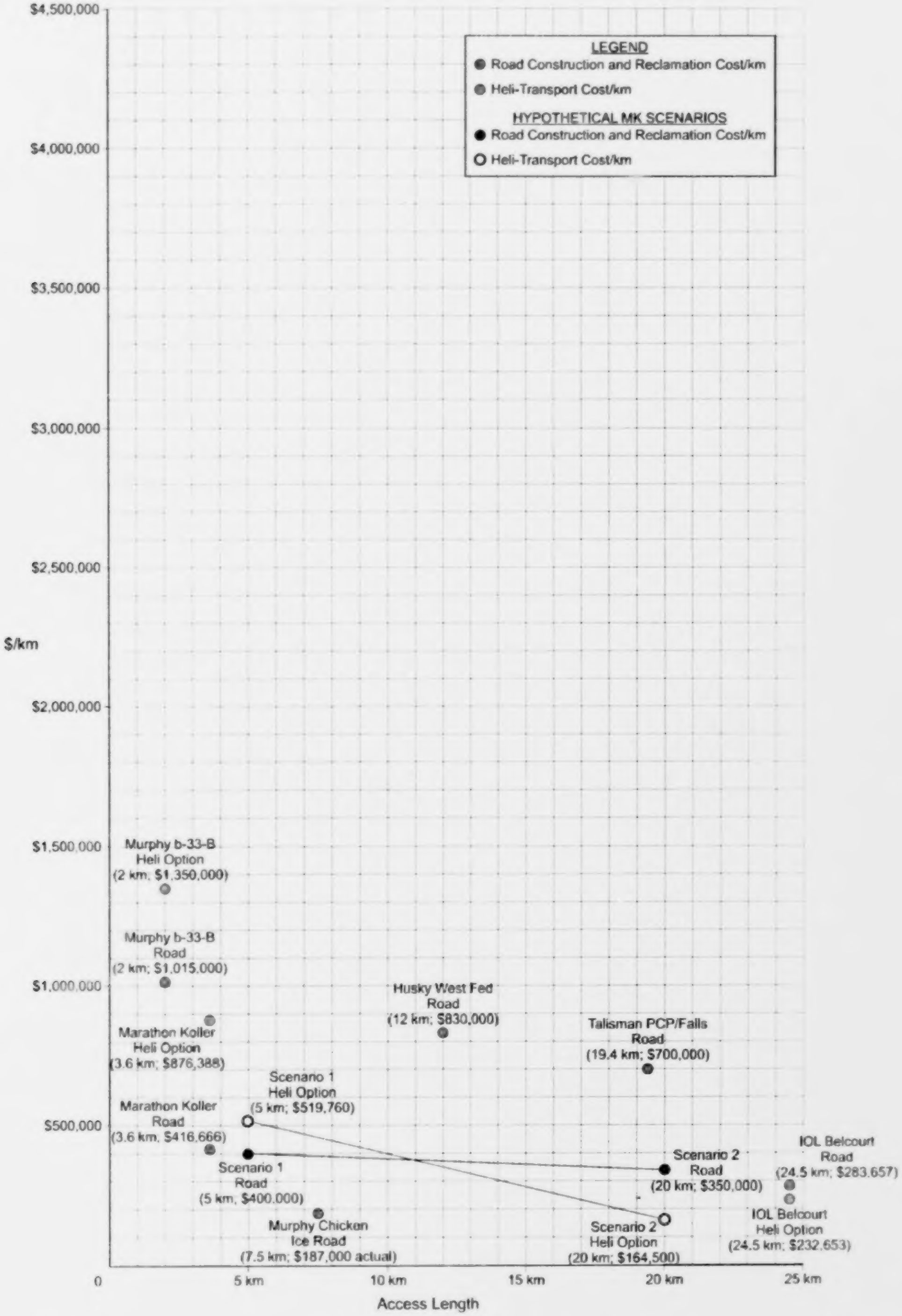


FIGURE 2B COMPARISON OF ROAD CONSTRUCTION AND HELICOPTER TRANSPORTATION COST ESTIMATES FOR VARIOUS EXPLORATION DRILLING PROJECTS IN MOUNTAINOUS AREAS OF NORTHEASTERN BC

3.0 GENERIC CASE STUDY COMPARISON OF PROBABLE HELIPORTABLE VS. CONVENTIONAL COSTS FOR THE MUSKWA-KECHIKA

In order to obtain a better understanding of potential capital costs implications of heliportable drilling in the MK, the present study has identified two hypothetical drilling location scenarios that might reasonably capture the range of costs associated with oil and gas exploration in the MK. Those scenarios are as follows:

Scenario 1: 2,700 m Mississippian target, directionally drilled with good seismic control; conventional access requires a 5 km road that includes 2 km along an existing seismic line, and 1 km along an open muskeg in a valley bottom with gentle terrain; black spruce forest grading to mature white spruce forest; crosses one fish bearing creek.

Scenario 2: 4,200 m Devonian target, directionally drilled with moderate seismic control; conventional access requires a 20 km road that includes 2 km along an existing access trail, 4 km along willow flats and muskeg, 14 km requires graded road construction including 1 km alpine construction and 3 km steeply ascending side hill construction, 14 km of clearing through subalpine Engelmann-subalpine fir forests; site in moderately confined north-south valley; 1 km immediately adjacent to high value wildlife habitat; less than 500 m from large mineral lick and First Nations traditional use site; crosses four fish bearing streams and the Kechika River.

Using these scenarios as the basis for a rough, cost comparison suggests that heliportable exploration drilling may tend to be more expensive for sites requiring relatively short access, but may be less than or at least similar to conventional road access for longer, more complex drilling targets (Table 2). At the present time, in cases where long access is required but targets do not require rigs with depth ratings greater than 3,400 m, it is likely that heliportable drilling in the scenario presented, would be less expensive than a conventional road accessed approach.

Government regulatory requirements concerning the allowable timing of operations in certain areas, requirements for use of low impact winter roads and the nature of imposed reclamation standards all will have significant implications for the cost of drilling in the MK and any differential between heliportable drilling and other approaches.

Heliportable costs are likely to become further reduced as experience is gained and as drilling rig availability and competitive equipment availability increase. Experience alone appears to have potential to significantly reduce costs. For example, in Berlie's (1995) report to the Ministry of Energy, Mines, and Petroleum Resources it was noted that over a five year period, Chevron reduced its drilling cost per meter on heliportable wells in New Guinea to one fifth the original cost.

TABLE 2

GENERIC CONVENTIONAL VS. HELIPORTABLE COST COMPARISON SCENARIOS*

Tasks	Scenario 1 (5 km Access)		Scenario 2 (20 km Access)	
	Heliportable	**Conventional**	**Heliportable**	**Conventional**
Planning and Environmental Studies	25K	35K	35K	70K
Surveying	15K	50K	15K	100K
Prepare Helicopter Staging Area	50K	N/A	50K	N/A
Conventional Road Construction	50K (assumes 1 km foothills construction between camp and well)	1,000K (4 km)	250K (assumes 1 km mountain construction between camp and well)	3,500K (14 km)
Low Impact Road Construction	N/A	200K (1 km)		1,200K (6 km)
Road Maintenance	50K	100K	50K	400K
Camp and Lease Construction	400K	50K	430K	50K
Drilling Rig Mobilization and Demobilization	500K	Not included	2,034K	Not included
Transportation Costs For Drilling and Completions	2,006K	Not Included	2,006K	Not included
Drilling (Rig day rate x 90-day well)	1,215K	1,215K	2,295K	1,530K
Road Reclamation	50K	1,000K	250K	3,500K
TOTAL	**4,361K**	**3,650K**	**7,415K**	**10,350K**
Road Const. and Reclamation Cost/km	100K	400K	250K	350K
Helicopter Transport Cost/km	520K	N/A	164K	N/A
Cost/km	**872K/km**	**730K/km**	**371K/km**	**518K/km**

*** Assumptions:**

Camp and Lease: Cost increment for heliportable attributable to helicopter support for 1-month construction period.

Road: Conventional mountain road construction cost is $250,000/km with the same cost for reclamation. Conventional foothills road construction cost is $50,000/km with the same cost for reclamation. Low impact road construction assumed to cost $200,000/km but having no requirement for reclamation (in 20 km scenario it is assumed that construction in year 1, drilling in year 2, meaning that low impact road segment must be re-established in year 2).

Drilling Rig: Rig for Scenario 1 @ $13,500/day (the same rig for heliportable and conventional). For Scenario 2 foreign heliportable rig @ $25,500/day and conventional rig @ $17,000/day. Assume $1 million additional mobilization of heliportable rig in Scenario 2.

Heliportable rig mobilization includes consumables and 50% consumable contingency. No cost included for conventional transportation costs for rig mobilization or servicing during drilling. These costs are assumed for heliportable rig. No costs included for drilling beyond day rate. Assumes water available on or near site.

Helicopters: Assumes Chinook 234 @$13,500/hr, can move 7 loads/hr to 5 km site and 3 loads/hour to 20 km site (Peterson pers. comm.). Assume 15 loads for lease construction equipment mobilization. Assume 125 loads for small rig (5 km mobilization), 75 loads demobilization. Assume 500 loads for large rig, (20 km mobilization), 300 loads demobilization. Mobilization assumes 50% over supply of consumables not used and must be backhauled. Assume 8 hours Bell 212/day during the drilling program or 720 hrs for a 90-day program. If additional rig fuel is required, a Chinook 234 could transport approximately 13.6 m^3 of fuel per trip or approximately 3,000 gallons, or 21,000 gallons/hr to a 5 km well site or 9,000 gallons/hr to a 20 km well site.

4.0 COST OF HELIPORTABLE DRILLING RIGS

Heliportable rigs, like conventional rigs range in cost, depending on their drilling depth capability. Mobilizing fees also vary widely depending on where the required rig is located prior to the job and any negotiated contractual arrangements. Mobilizing a medium to large local rig may cost in the vicinity of $500,000 while mobilizing the same rig from a foreign location to northeastern BC could range be in the range of $1.5 million to about $2.5 million CDN (Crowson pers. com). At the time of this review, there were four heliportable rigs in North America with the remainder operating in South America and the South Pacific region, Indonesia and New Guinea. The current costs and location of these rigs and approximate mobilization fees are summarized in Table 3. It is anticipated that over time, any increased North American market demand would result in increased heliportable rig availability and potentially some attendant reduction in costs.

4.1 Conversion of Conventional Rigs and Custom Designed Heliportable Rigs

During the course of this study, comment was received that the concern over local heliportable rig availability might be met through conversion of existing conventional rigs to this purpose. The assumption here being that this would in theory eliminate foreign mobilization fees (estimated above to be in excess of $1.5 million), premiums that might be associated with taking a normally active rig out of it's area of active service and potentially reduce concern over delays. The cost of converting a conventional rig to a heliportable rig, which would typically be born by a drilling company and not an oil and gas company, is dependent on the size of the rig and rig design. Many of the larger components such as the drawworks are welded assemblies and would have to be cut and redesigned for bolt-together assembly. Conventional mud pumps and tankage would also require modification or replacement. Cost estimates from previous studies and from interviews conducted during the present study suggest that these costs could be in the range of $2 million to $5 million and take perhaps four to six months (Fire Creek Resources Ltd. 2000, Crowson pers. comm.).

Rough cost estimates obtained during this study to custom build a heliportable rig were variable and dependent on whether the rig was built in Canada or the US. These rough estimates ranged from $12 million CDN to $20 million US (Crowson, Luft, Pare pers. comm.). Costs to build a heliportable rig capable of drilling to 3,400 m were estimated at $6 million to $7 million (Pare pers. comm.). Construction time to build a deep rated heliportable rig was estimated to take approximately 8 to 10 months (Crowson pers. comm.).

While redesigning a conventional rig appears to be more cost effective than building a new heliportable rig, this approach appears to be strongly disfavored by the drilling contractors as it requires taking a conventional rig out of normal service and has potential to result in a less purpose-built design integrity.

TABLE 3

2002 HELIPORTABLE DRILLING RIG RATES AND MOBILIZATION FEES [1]

Company	Drilling Rig	Rate/day	Depth Rating (m)	Mobilization Fee ($)
Drillers Technology Corp., Calgary, Alberta [2] (CDN)	Rig No. 4	12,000 to 14,000	3,400	140,000 from Calgary to Fort St. John (winter) 80,000 to 90,000 from Fort St. John or Fort Nelson
	Rig No. 5	12,000 to 14,000	3,400	140,000 from Calgary to Fort St. John (winter)
	Rig No. 6	12,000 to 14,000	3,400	140,000 from Calgary to Fort St. John (winter)
	Rig No. 7	12,000 to 14,000	3,400	140,000 from Calgary to Fort St. John (winter)
Parker Drilling, Houston Texas [3] (USD)	Rig 115	16,000 to 18,000	5,486	1.5 million currently in Indonesia
	Rig 131	16,000 to 18,000	5,486	1.5 million currently in Peru
	Rig 140	16,000 to 18,000	5,486	1.5 million currently in Papua New Guinea
	Rig 145	16,000 to 18,000	5,486	1.5 million currently in Peru
	Rig 146	16,000 to 18,000	~6,400	1.5 million currently in Indonesia
	Rig 160	16,000 to 18,000	5,486	1.5 million currently in Papua New Guinea
	Rig 188	20,000 to 22,000	>6,400	1.5 million currently in New Zealand
	Rig 190	16,000 to 18,000	5,486	1.5 million currently in Indonesia
	Rig 200	16,000 to 18,000	5,486	incomplete rig- not available
	Rig 206	16,000 to 18,000	~6,400	1.5 million currently in Indonesia
	Rig 223	16,000 to 18,000	5,486	1.5 million currently in Columbia
	Rig 225	16,000 to 18,000	~6,400	1.5 million currently in Indonesia
	Rig 226	20,000 to 22,000	~6,400	1.5 million currently in Papua New Guinea
	Rig 228	20,000 to 22,000	6,705	1.5 million currently in Peru
	Rig 250	16,000 to 18,000	~6,400	1.5 million currently in Peru
	Rig 255	20,000 to 22,000	6,705	1.5 million currently in Bolivia
Helmerich and Payne Drilling, Tulsa Oklahoma [4] (USD)	Rig 170	17,000	9,1444	400,000 USD
	IDECO #22	16,000 to 18,000	5,486	1 million
	IDECO #23	16,000 to 18,000	5,486	1 million

1. All rates negotiable.
2. Pare pers. comm.
3. Crowson pers. comm.
4. Atwell pers. comm.

Information on drilling depths is provided in Technical Report, Appendix A.

USD = United States dollars, CND = Canadian dollars

4.2 Relief Drilling Rig and Blow-out Control Costs

A requirement to provide on-demand heliportable relief well capability as a contingency for blow-out control would likely increase the total cost of drilling by between about $500,000 to $2.1 million (40% to 100% of low end and high end heliportable rig day rates x 90-day drilling program).

As discussed in the Technical Report (Section 8.4), most well blow-outs are more effectively and rapidly controlled by capping rather than bringing in a relief rig. The primary need for a relief rig arises in the very rare cases where the well head and casing cannot be practically accessed by heavy equipment, for example where the well site is underwater (*e.g.*, offshore drilling) or where the casing must be reached more than about 3 m to 10 m below ground (Miller, Wheeler pers. comm.). For a heliportable drilling program, the requirement for a relief rig, could be achieved either by mobilizing any available heliportable rigs with sufficient depth capability or by constructing a new access road to the well site and mobilizing a conventional rig. In this latter case, potentially significant road costs could be incurred.

In the case of mobilizing a second heliportable rig, a company could choose to either reserve a second rig and incur associated standby charges or rely on assumed availability. Standby charges for a relief rig could range from about 40% to 100% of the normal daily charge out rate of the rig, depending on pre-drilling contractual negotiations (Pare pers. comm.). This cost may be offset to some extent, if the relief well capability can be provided by a shallower depth rated heliportable rig.

Contingency planning for a blow-out at a heliportable well site includes extra costs for stockpiling of supplies (*e.g.*, drilling mud, chemicals) and equipment (*e.g.*, extra blow-out preventer (BOP) and flanges). Assuming these are never used, there is also a corresponding cost associated with removing these same materials offsite following well completion.

In the case of a larger volume uncontrolled liquids release, greater cost would be potentially incurred at a heliportable well site in conjunction with the need to heli-transport additional pieces of heavy equipment, as well as for activities such as helicopter site inspection.

5.0 HELICOPTER RATES

A range of heavy lift helicopters with significant lift capacity suitable for a heliportable drilling program are available in North America (Table 4). Heavy lift helicopters are used to transport heavy equipment for well site and camp construction and reclamation, mobilization and demobilization of the drilling rig and transport of tubulars and bulk consumables (mud, chemicals). A medium lift helicopter such as a Bell 212 or the smaller A-Star, can be used during the drilling program to provide routine transportation needs or to selectively reduce flying expenses associated with larger machines where the loads do not warrant it. Substantial cost savings can be achieved through use of an experienced "loadmaster" and proper load planning. If adequate rig fuel cannot be stockpiled during the initial mobilization then there may be a need for additional periodic heavy lift service during the drilling program. A Chinook 234 can move approximately 13.6 m^3/trip or 3,000 gallons. Helicopter usage can be further optimized, with attendant savings where more than one well was being served in the same general area at one time.

Helicopter costs are also significantly reduced if the camp is located at the well site, since this reduces the requirement of transporting the crew via helicopter between the staging area and well site. Ferrying charges are usually associated with moving a heavy lift helicopter. For example, transporting a Chinook 234 from Fort St. John to a heliportable staging area may cost $25,000 and from Vancouver may cost $150,000 (McDermid pers. comm.). It may be that perhaps up to four heavy lift helicopter mobilizations could occur during a routine heliportable drill.

Helicopter companies typically charge a 4-hour daily minimum for helicopters (Table 4), however this may vary depending on the amount of work that is guaranteed and the particular helicopter company. If a certain number of hours of operation can be guaranteed by the proponent, then rates are generally reduced. For larger contracts such as would be associated with a heliportable drilling program, it would be likely that perhaps $300,000 to $500,000 could be saved through such contract negotiations. Fuel costs typically range between $0.50 to $0.90 per litre (McDermid pers. comm.).

TABLE 4

HELICOPTER RATES

	Name	**Rate / hr (fuel not included)**	**Fuel Consumption (L/hr) / Cost ($0.50 to $0.90/L)**
Heavy Lift Helicopter	Boeing Chinook 234	$13,500 - $14,000	1,530 / $765 - $1,377
	Boeing Vertol 107 (II)	$4,700 - $5,200	630 / $315 - $567
	Sikorsky S-64	$10,000 - $12,000	1,985 / $992.50 - $1,786.50
	Sikorsky S-61A	$4,500 - $5,000	640 / $320 - $576
	Sikorsky S-61L	$4,500 - $5,000	N/A
	Kamov Ka32A11BC	$5,500 -$6,000	N/A
	Super Puma	N/A	N/A
Medium Lift Helicopter	Bell 212	$2,525	375 / $187.50 -$337.50
	A-Star	$1,200	N/A

Sources: McDermid, Peterson, Taylor pers. comm.

5.1 Helicopter Planning and Logistics

To reduce helicopter costs, there can be economic efficiencies to planning the helicopter specifications to coincide with the individual lift requirements such that the more expensive heavy lift helicopters are not underutilized. For example, if the majority of the loads are 10,000 lbs, and only one or two loads are 15,000 lbs, a helicopter capable of lifting 10,000 lbs. will be far more efficient and economically viable than underutilizing a higher capacity helicopter for all the loads (Taylor pers. comm.). The helicopter that can lift the most weight is not always the most efficient and cost effective. While a Chinook 234 is an ideal helicopter for all heavy lift work, a Vertol 107, Kamov, Bell 212 or equivalent will likely be more practical for more moderate loads (Peterson, Taylor pers. comm.). As previously mentioned, use of experienced helicopter loadmasters at both the staging area and well site also optimizes the efficient movement of materials and reduces cost. Loadmasters are often included as part of the helicopter company service package on larger projects. While pre-planning flight routes is part of the environmental mitigation that would be applied to a heliportable drilling program in the MK, it can also be used to reduce costs associated with load handling. Avoiding long climbs, for example, can affect turn around times and ultimately price per kilo (Taylor pers. comm.).

5.2 24-Hour Operation

Workers' Compensation Board of BC (WCB) regulations only require that adequate emergency needs are met onsite and appropriate transportation is available when conditions become suitable. However there may be some desire by industry to provide 24-hour all-weather access. As discussed in the Technical Report (Section 9.0), in order to be technically feasible, heliportable drilling must either provide for 24-hour all-weather access and/or ensure that all emergency medical needs can be effectively met onsite. Both contingencies have associated costs.

If company policy or regulators required 24-hour well site access, helicopters, crews and landing areas would have to be set up for Night Visual Flying Rules (Night VFR) and possibly a full Instrument Landing System (ILS). A 24-hour, on demand, helicopter serviced operation would require the following additional items and costs:

- a twin engine helicopter (*e.g.*, Bell 212), with two Instrument Flight Rules (IFR) trained pilots and an engineer/mechanic. IFR equipped helicopters with crew are typically $4000/hr (this compares with a normal Bell 212 dry rate of approximately $2,525/hr);
- a non-directional beacon approach system (cost approximately $100,000);
- an optional ILS. While not essential, an ILS would cost about $1 million and require approximately six months for an approval (Adamson pers. comm.).

6.0 OTHER HELIPORTABLE DRILLING COST CONSIDERATIONS

6.1 Stockpiling

In a heliportable drilling program, an important cost and mitigation factor involves ensuring that both anticipated and back-up supplies are stockpiled on the well site in order to allow management of contingencies and minimization of down time. This may mean having as much as 40% or 50% more mud and chemicals onsite as a contingency depending on the location and drill. This requires an upfront cost for mud and chemicals that is not required on a conventional well site where supplies are trucked in on an as needed basis. These additional supplies, if unconsumed must also then be backhauled as part of the demobilization costs. This latter cost could conceivably range from about $50,000 to close to $500,000 for transportation costs depending on the rig and amount of material to be back hauled.

6.2 Rig and Camp Water

Obtaining and maintaining an adequate water supply was identified as a significant concern by both Murphy and IOL in their respective evaluations of heliportable drilling (Murphy 1996, IOL 1995). This factor added an incremental $170,000 to Murphy's cost estimate for heliportable drilling relative to options for water supply with conventional access. Using helicopters to transport rig water would add significantly to heliportable costs (a Chinook 234 can haul approximately 13.6 m^3 or 3,000 gallons per trip at a cost of $13,500/hr). Alpine locations can in general be expected to have reduced probability of achieving an adequate groundwater source relative to sites at lower elevations. Summer operations would allow for temporary overland piping and pumping systems that may alternately meet this need at a much reduced cost.

6.3 Casing Drilling

Recent development of "casing drilling" whereby the hole is drilled with casing instead of drill pipe and then cemented in, has the potential to reduce the need for hauling additional loads of drill pipe and reduce the total time to drill and complete the well (Pare pers. comm.). Casing drilling also has potential to increase the depth capacity of a given rig. For example a 3,400 m heliportable rig could casing drill a 4,500 m hole because the rig does not have to pull the casing back out of the well. This eliminates the need for drill pipe, the cost of drill pipe, the cost of flying drill pipe and can potentially shorten drilling time by reducing the number of trips necessary to change drill bits and set casing. Drilling time has been suggested to be shortened by up to 30% using this emerging technology (Oil and Gas International 2001). Drilling conditions in the MK may or may not accommodate this technology at the present time.

6.4 First Aid Requirements

Onsite medical needs must be in compliance with the Workers' Compensation Board of BC Occupational Health and Safety Regulations (see Section 10.0 of the Technical Report). On a heliportable drill site, it is expected that the number of workers per shift may exceed 30 workers (well site and camp combined) and based on Schedule 1, Table 1 (OHS Regulation Part 33), this number requires a Level 3 kit, First Aid Room, emergency transport vehicle (ETV) equipment and a Level 3 attendant are required. Costs associated with this include a 12 x 44 ft. First Aid Room that can provide overnight care for two injured workers at approximately $140.00/day (Mount View Trailer Sales pers. comm.) (this does not include propane costs), two Level 3 attendant equipped with first aid supplies at $700.00/day (Alpha Safety pers. comm.) and an argo/or snowmobile equipped to carry a injured worker to the First Aid Room if the distance is of short duration.

At a conventional road-accessed well site with the same number of workers, these requirements would be the same. Additional costs associated with heliportable first aid requirements would include transport of the equipment via helicopter.

In both scenarios, a seriously injured worker in a remote location primarily relies on helicopter transport for the most efficient evacuation.

6.5 Insurance

Helicopter insurance will likely be required by the company. This additional cost could range from $20,000 to $40,000.

7.0 POTENTIAL COSTS RELATED TO WEATHER DELAYS, SEASONAL CONDITIONS AND BLOW-OUTS

7.1 Weather Delays and Seasonal Conditions

Weather delays encountered during either a conventional or heliportable operation can be expected to increase costs by incurring standby charges and/or by delaying completion of critical phases of the project. Weather delays associated with a conventional road accessed well site can occur in the summer as a result of rain, as a result of delays in freeze-up, and early spring thaw. As a general environmental protection measure, in the event of thawed soils construction and travel along the access road is postponed or contingency measures implemented (*e.g.*, suspend travel to early evening or early morning, install geotextile, swamp mats, etc) in order to minimize terrain disturbance, soil structure damage, erosion, excessive rutting and tracking of mud. These latter approaches all add to construction and road maintenance costs. Rigs may also be stranded on sites where the drilling program cannot be completed prior to spring break-up. In a similar way, in the event of a late freeze-up, commencement and completion of winter roads may be delayed and drilling may not commence as early as scheduled and potentially be suspended until the next winter. For longer winter roads this may be unavoidable. This can result in additional standby charges as well as delays in tie-in of any discovered hydrocarbons. The option to combine winter road construction with heliportable summer access to some extent would offset these potential seasonal effects, though still represents a substantially increased time increment relative to heliportable drilling.

Helicopter shut down due to no-fly conditions potentially encountered during periods of fog/low cloud cover, heavy precipitation, icing or high wind, typically occurs for a few hours of a given day. Delays of this duration would have minimal potential to impact exploration costs.

8.0 RECLAMATION COST CONSIDERATIONS

Reclamation of roads associated with conventional access typically requires restoring grades, replacing topsoil, restoration of watercourses (removal of vehicle crossing structures), seeding and using rollback. These efforts are comparable in many ways to the initial construction effort such that, as a general guide, the cost of reclamation generally approximates the cost of road construction. Depending on the reclamation requirements of the MK, costs associated with reclamation may add significantly to the overall cost of a given exploration project. Where there is a requirement to more aggressively reclaim and monitor reclamation, a company could encounter potentially significant manpower and financial commitment. Reclamation costs would significantly increase if for example, reforestation with coniferous seedlings and/or larger tree stock was a requirement.

A primary difference between conventional road accessed drilling and heliportable drilling is that the heliportable option does not require reclamation beyond the well site, camp and staging area. While impacts and reclamation costs can be significantly reduced with low impact winter roads, opportunities to carry this practice out in the MK are very site-specific.

9.0 INVESTMENT OPPORTUNITIES, JOB CREATION AND GOVERNMENT REVENUE

Forcing the oil and gas industry to undertake heliportable drilling in the MK will have a number of economic effects, the nature of which will be contingent on the manner in which a heliportable drilling policy and any associated guidelines are developed, clearly articulated and implemented. Assessing the economic impacts of a decision to encourage heliportable drilling on intangibles such as wildlife and wilderness is difficult, but clearly has long-term economic and social benefits for those who rely on the integrity of these resources, including the tourism industry. Short-term adverse economic impacts on guide-outfitting could still occur in proximity to heliportable drilling depending on how the activity is managed.

Knowing what the response of the oil and gas industry would be to a requirement for heliportable drilling is unclear. For some prospects likely to be identified in the MK, the imposition of a requirement for heliportable drilling may, depending on energy prices, result in reduced projected profit to investment ratios such that some lands are not posted or not as competitively bid. If this effect results in some reduction in land prices, it may provide feedback such that ratios become more favorable. A saving of several million on a land sale may make up any adverse economics associated with a heliportable drilling prospect. Overall, the magnitude of this response can be expected to be contingent on the extent to which industry is expected to fully absorb the incremental costs, strength of the energy market, the presence of fiscal incentives or tenure incentives, changing heliportable rig availability, emerging technology and the unfolding exploration history in the area.

The encouragement and conduct of heliportable drilling will reduce some employment in the road construction sector. This will be potentially offset by increased activity in the helicopter industry and retention of other long-term local economic benefits (*e.g.*, guide-outfitting and tourism).

A range of likely economic costs and benefits associated with the promotion of heliportable drilling in the MK are summarized in Table 5.

TABLE 5

POTENTIAL ECONOMIC COSTS AND BENEFITS OF HELIPORTABLE DRILLING IN THE MK

Costs	Benefits
Public Recreation and Tourism Investment in Northeastern BC	
On a per well basis, short-term noise associated with heliportable drilling may result in loss of tourism opportunities on a site-specific basis.	Eliminates long-term (>2 year) landscape aesthetic impacts.
	Would likely help maintain or promote long-term tourism in northeastern BC through reduced landscape impacts and public relations value.
	Would likely help maintain or promote long-term guide outfitter business in northeastern BC through reduced landscape impacts.
Investment and Employment in BC	
Companies may not bid on land subject to heliportable requirement or where there is uncertainty as to criteria used to determine its application.	Creates more certainty for land if government policies/regulations identify areas or site criteria where heliportable exploration is required, appropriate or optional.
May divert attention to land elsewhere in, or outside the province. Reasons for this would include perceived capital risk (cost) relative to potential gain; unfamiliarity with technology and cost implications, perceived increased safety and emergency response handicaps/compromise.	Promotes new technology and diversification of drilling industry.
	Increased employment in helicopter industry.
Effect may be exaggerated where industry obliged to assume heliportable operation with no road access.	New joint venture training career opportunities and new technology exposure for First Nations and others.
Reduced employment in conventional road construction	Reduced loss or alteration of productive forest cover caused by road construction.
Increased forestry or future mining costs as fewer roads subsidized by oil and gas development.	Greater allowance of drilling outside of winter season may benefit service sector.
	May increase amount of seismic related expenditure and employment in areas where heliportable is required or probable.

TABLE 5 Cont'd

Costs	Benefits
Exploration and Development Economics	
Initial economic cost contingent on length and location of road alternative, reclamation standard, and site-specific timing restrictions.	*Initial economic benefit contingent on length and location of road alternative, reclamation standard and site-specific timing restrictions.*
Increased costs for short to medium length access relative to conventional road access where environmental and geotechnical constraints are few.	Reduced costs for planning, assessment, road engineering and approval (particularly with experience).
No upfront road construction to off set pipeline construction costs or development well access if well successful.	Reduction in front end time for approvals and construction may accelerate time for tie-in and with it accelerate the revenue stream compared to sites requiring construction of long complex access and or interrupted drilling due to breakup or freeze-up.
May slightly increase expenditures on seismic programs to increase certainty around drilling target.	Eliminates cost of road construction and reclamation (and maintenance if carried through for exploration phase).
Potential significant costs if a water source is not available in close proximity to the site.	Costs equivalent or reduced relative to conventional road access for longer more complex roads.
Significant mobilization costs or scheduling requirements where rig with adequate depth capability is not readily available or must be procured from distant location.	May reduce drilling costs and increase probability of success due to better well site optimization and reduced pressure for environmentally driven directional drilling.
Potential to incur significant costs where there is a requirement to guarantee relief rig availability.	May increase industry access to areas formally or informally off limits due to environmental sensitivity.
May be significant increase in costs if rig and camp water have to be flown in.	Use of heliportable drilling will likely lead to a marketplace response (*e.g.*, increased rig availability at a lower cost) which will reduce the overall cost of future drilling using this approach and increase rig availability.
May be significant increase in cost for blow-out control (particularly containment and clean-up costs) where uncontrolled liquids release.	Ability for summer drilling in some locations may provide a greater drilling activity period (current total winter season is 120 days for access construction and drilling). Helicopter activities could extend seasonally June to October or November to May, or even year round depending on site-specifics. The net effect may be a quicker turn around between exploration and production.
May create precedent that forces use and/or more aggressive application of heliportable drilling in other locations with adverse incremental hard cost differentials.	

10.0 CONCLUSION

While detailed modeling of anticipated impacts to government revenues consequent from a decision on heliportable drilling is well beyond the scope of the present study, it is our view that site-specific and judicious promotion of heliportable drilling within the MK has potential to result in more sustainable long-term economic benefit and employment from this area and for the province overall with a reduction in environmental and related social costs. Integration of heliportable technology into the petroleum sector in northeastern BC may somewhat diversify and strengthen the base for local contracting and joint ventures.

11.0 RECOMMENDATIONS

1. Developing a clear policy with regard to the use of heliportable drilling in the MK should be undertaken in order to reduce uncertainty within the industry and among resource users. This will likely provide benefits for all groups concerned and lead to the more efficient use of capital and development of energy resources. In the course of developing any policy or guidelines, the real need for any requirement for on-demand relief well capability and access or 24-hour on-demand helicopter service should be questioned. These requirements in and of themselves could impose a significant and likely unwarranted cost premium for management of contingencies.
2. Where the risks associated with heliportable drilling are deemed acceptable, guidelines should be prepared which are identified prior to a land posting and are location specific or are attached to a land posting, and known prior to bids being issued.
3. The feasibility of heliportable drilling could be increased by providing financial incentives to the petroleum industry where commitments are made to use this approach. These incentives would have to be based on a reasonable comparison with alternate low impact surface access that would be otherwise pursued. The need for incentives may decrease as the marketplace responds to the demand (e.g., by procurement of deeper rated and/or more rigs). Options to reduce the economic premiums that may be associated with heliportable drilling could include the following incentives:

   a) royalty relief (*e.g.*, 30% to 50%) on existing or any future production;
   b) increased exploration acreage retention for heliportable wells;
   c) tenure extensions;
   d) bid bonus applied to land sales where proponent commits to heliportable drilling (*e.g.*, land bid prices which did not include commitments to heliportable drill in certain locations or under certain clear conditions would be discounted (*e.g.*,10%) thus favoring bidders who would commit); and
   e) accessing additional funding support through the Oil and Gas Commission Environmental Fund.

12.0 REFERENCES

12.1 Personal Communications

Adamson, Murray. Canadian Helicopters. Fort St. John, British Columbia.

Alpha Safety. Fort St. John, British Columbia.

Atwell, Dale. Helmerich and Payne Drilling Inc. Tulsa, Oklahoma.

Crowson, Randy. Parker Drilling. Houston, Texas.

Luft, Barry. Fire Creek Resources Ltd. Calgary, Alberta.

McDermid, Gary. Helifor Industries. Vancouver, British Columbia.

Miller, Mike. Safety Boss. Calgary, Alberta.

Mount View Trailer Sales. Grande Prairie, Alberta.

Pare, Treena. Drillers Technology Corp. Calgary, Alberta.

Patterson, Bernie. Marathon Canada Ltd. Calgary, Alberta.

Peterson, Todd. Columbia Helicopters. Portland, Oregon.

Pow, Murray. Husky Energy Inc. Calgary, Alberta.

Staniland, Rob. Talisman Energy Inc., Calgary, Alberta.

Taylor, Corey. Vancouver Island Helicopters. Fort St. John, British Columbia.

Wheeler, Harris. AAEA Ltd. Charlie Lake, British Columbia.

12.2 Literature Cited

Fire Creek Resources Ltd. 2001a. Logistics and Cost Study for a Heli-portable Drilling Alternative. Marathon Koller Creek d-40-J/94-G-3.

Fire Creek Resources Ltd. 2001b. Proposal for Heli-portable Drilling Operations. Ricks Ladyfern a-98-H/94-H-1 and c-87-H/94-H-1.

Imperial Oil Limited. 1995. Risk and Cost Analyses of Access Options for Drilling Imperial Belcourt a-53-K / 93-I-8. February 1995. 40 pp + appendices.

Murphy Oil Company Ltd. 1996. Evaluation of Access Methods for Exploration Drilling within BC P&NG Tenure 951060B Murphy Gulf Chicken Creek B/94-G-6. October 1996.

Oil and Gas International. 2002. Conoco, Tesco unveil groundbreaking way to break ground. 2/12/2002-OGI. 24/7. http://www.oilandgasinternational.com/departments/drilling_completion/feb02_conoco.html.

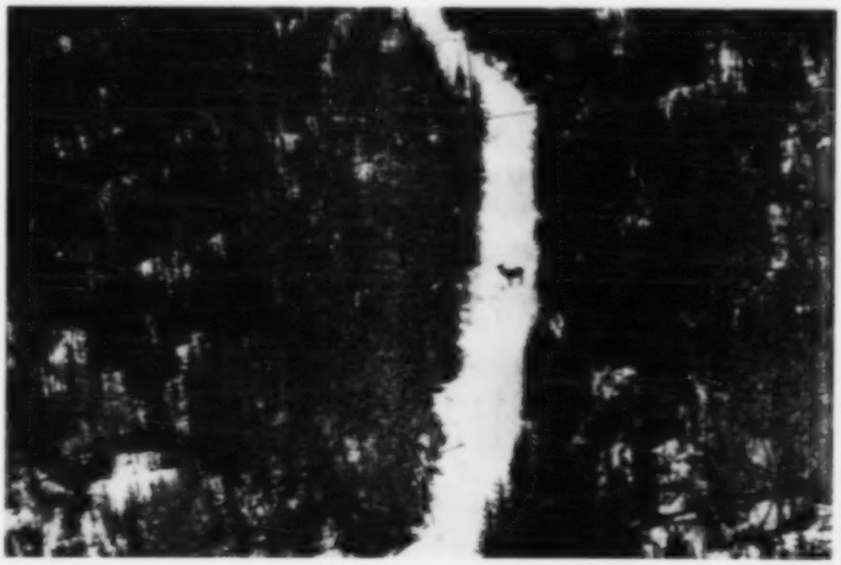
APPENDIX A

COST ANALYSIS FROM PREVIOUS PROJECTS

Imperial Oil Limited (a-53-K / 93-I-8) Belcourt Creek, 1995
Murphy Oil Company (b-33-B / 94-G-6), 1996
Marathon Canada Ltd. (d-40-J / d4-G-3), 2001

MUSKWA-KECHIKA MANAGEMENT AREA HELIPORTABLE DRILLING FEASIBILITY STUDY

SYNTHESIS, CONCLUSION AND RECOMMENDATIONS



Prepared for:

BC Ministry of Sustainable
Resource Management,
Muskwa-Kechika
Advisory Board
and the
BC Oil and Gas Commission

Prepared by:

Randal Glaholt and Lois Pittaway

TERA Environmental Consultants
Suite 1100, 815 - 8th Avenue S.W.
Calgary, Alberta T2P 3P2

Brian Churchill

Chillborne Environmental Services
SS2 Site 22 Comp 23
Fort St. John, BC V1J 4M7

Harris Wheeler
AAEA Ltd.
Charlie Lake, BC V0C 1H0

June 2002
2555

EXECUTIVE SUMMARY

When considering the range of issues associated with heliportable exploration drilling, it is clear the government must balance a broader set of social and economic costs and benefits associated with heliportable drilling compared with the petroleum industry. Factors which affect the public and First Nation's acceptance of oil and gas development can still have significant cost implications for the industry through either delays required for consultation and/or pressure for activity exclusion or other restrictions. A range of cost and benefit variables associated with heliportable exploration drilling are summarized. Depending on the variable, the cost or benefit may be more immediately felt by the government, the public, industry or shared by all groups.

Heliportable drilling relative to conventional road access must be compared, on a site-specific basis, with whatever least impact, surface access alternative a given prospect may present. For example, a site may be readily accessed by an existing seismic line, road or snow road, and in doing so, must be compared to the "costs" associated with a heliportable approach (as well as some of the benefits).

Forcing a company to assume large incremental "costs" for marginal environmental or social benefit will create a general disincentive for exploration where the potential return on investment is perceived as low.

Based on review of the various costs and benefits, six *Critical Factors* were identified that are believed to represent the most important issues when considering the site-specific feasibility of heliportable drilling. These are: environmental sensitivity; availability of low impact alternatives; helicopter site risk; capital cost; blow-out risk and worker safety; and presence of sour gas.

Environmental sensitivity, availability of low impact alternatives and helicopter site risk have a direct bearing on capital cost and will vary widely from site to site. Industry's demonstrated ability to manage blow-out risk and to operate safely in sour gas environments, combined with the probable level of planning and expertise, which would be applied to heliportable drilling, suggests that blow-out risk and presence of sour gas, should be less critical considerations concerning heliportable drilling feasibility. These two factors are also relatively independent of cost. In the absence of adequate contingency planning, however, it is clear that a blow-out, involving high volume uncontrolled liquids release would have substantially greater cost implications on a heliportable project.

At least three approaches to decision making can be used in regard to assessing heliportable feasibility: formal quantitative cost-benefit analysis; quantitative ranking of individual sites or areas; and/or through a collaborative decision making process. None of these approaches are necessarily exclusive. Applying rankings and scores to the identified *Critical Factors* in terms of whether an individual site or region within the MK is more or less suitable for heliportable drilling can be used to systematically evaluate the overall feasibility of the site or area for heliportable drilling. It also illustrates the sensitivity of the evaluation to the various factors and the importance assigned to them. This approach is used on two hypothetical examples modeled after probable scenarios likely to be encountered in the MK.

In a general sense, there does not appear to be any basis for concluding that heliportable drilling in the MK is not feasible and should not be included in the range of low impact options acceptable to the MK resource managers. There will, however, be site-specific circumstances where it is relatively more or less feasible. Regulators could decide whether they were inclined to require heliportable drilling by location, by circumstance or to let the company decide.

Within the MK, it is clear there are likely to be locations proposed for drilling which will have conventional initial access "costs" exceeding that of heliportable access, where the environmental consequences of exploration roads will be high and where the potential economic reward of a prospect may be high. Heliportable drilling would appear to be a feasible, environmentally sound and safe approach to petroleum exploration in these cases.

In cases where estimated costs for heliportable drilling significantly exceed conventional surface access approaches (with expected emphasis on low impact approaches), the feasibility will depend on industry's valuation of the economic risks, the extent to which these can be offset by incentives and the government and industry's confidence in the proponent's ability to adequately manage environmental and human safety risks. From the information examined, there appears to be reasonably compelling evidence to suggest that these latter factors can be managed to a level at least equivalent to that associated with conventional surface accessed well sites.

A summary of the recommendations are as follows:

1. Heliportable drilling should be included in the range of land use management tools used by MK resource managers.
2. Developing a clear policy and guidelines with regard to the use of heliportable drilling in the MK should be undertaken in order to reduce uncertainty within the industry and among resource users prior to land posting.
3. In the event a policy decision is made which endorses the site-specific application of heliportable drilling, a set of best practices should be developed.
4. Consideration should be given to conducting an initial heliportable drill as a pilot study to facilitate the implementation and to promote refinement of any subsequent guidelines and procedures.
5. Identifying and mapping areas where the potential for low impact alternatives exist, as well as areas which may be more suited to helicopter access only should be considered.
6. Consideration should be given to increasing the feasibility of heliportable drilling by providing financial incentives to the petroleum industry where commitments are made to use this access approach.
7. The practicality and economics of heliportable only access for the operations phase of oil and gas development should be explored further.

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY i

1.0 INTRODUCTION 1

2.0 COST BENEFIT ANALYSIS 2
- 2.1 Qualitative Cost-Benefit Comparison 2
- 2.2 Other Considerations 8

3.0 CRITICAL FACTORS AND DECISION MAKING 9
- 3.1 Decision Making 11
- 3.2 Heliportable Drilling Suitability and Critical Factors 12
  - 3.2.1 Environmental Sensitivity 12
  - 3.2.2 Availability of Low Impact Alternatives 13
  - 3.2.3 Helicopter Risk 13
  - 3.2.4 Capital Cost 14
  - 3.2.5 Blow-Out Risk and Worker Safety 15
  - 3.2.6 Sour Gas 16

4.0 DECISION MATRIX 17

5.0 CONCLUSION 19

6.0 RECOMMENDATIONS 20

7.0 REFERENCES 22

LIST OF TABLES

Table 1 Cost Benefit Analysis of Heliportable Drilling in the MK 4
Table 2 Critical Factors and Considerations for Heliportable Drilling 10
Table 3 Decision Matrix 18

1.0 INTRODUCTION

In this report the results of the investigations into the key technical, environmental and cost implications of heliportable drilling are summarized and presented in the form of a cost-benefit comparison. This summary has been used to identify a range of criteria that should form the basis of decision making and the development of policy, guidelines and operational decision making for heliportable drilling. A numerically based decision matrix is provided using the identified criteria to facilitate systematic evaluation of important factors and to ultimately support decision making. Using the decision matrix, two hypothetical well location scenarios are used to explore the sensitivity of the criteria to various weighting factors and valuation scores. The report concludes with a number of recommendations.

2.0 COST BENEFIT ANALYSIS

In the public sector, formal cost-benefit analysis compares the monetary benefits and costs of government actions aimed at improving public well being (Moore 1995). Conventional quantitative cost-benefit analysis, to evaluate the merits of government action concerning heliportable drilling would require translation of it's positive and negative effects into a common measure, usually dollars. This conversion process requires many assumptions and is invariably controversial. For example, questions such as "what is the value of the current MK landscape aesthetic and the cost of changes to it?" or "what is the economic value of seeing an elk or catching a bull trout?" have multiple "right" answers depending on the analytical guidelines and values applied. We can expect the environmental "costs" and costs to the tourism industry (assuming the general public or foreign paying tourists prefer a pristine wilderness experience) of conventional road construction in the MK to be in most cases, more than heliportable. Attaching a dollar value to these costs is challenging. Similarly, accurately projecting the possible change in investment in the oil and gas sector, should heliportable drilling in certain locations be made mandatory, is also likely to be an error prone or very approximate process.

The financial resources required for "rigorous" cost-benefit analysis, particularly where it attempts to deal with intangibles and public goods which are not readily monetized are typically very costly, time consuming and have raised the concern that the process may get in the way of the government implementing timely and effective regulatory decisions in the publics best interest (Moore 1995). Moore (1995) provides examples where the US Environmental Protection Agency used cost-benefit analysis between 1981 and 1986 to guide it's major rulings. The average cost of cost-benefit analysis for seventeen major rulings averaged $675,000 US per rule.

Doing a less rigorous study increases the risk that the cost-benefit analysis may show a net benefit because it failed to consider or value the loss of a particular resource. For example, a determination of the net benefit of heliportable drilling in the MK could be flawed because it failed to accurately predict the effects of the noise of intensive summer time helicopter activity on foreign tourism to the area relative to that of a seasonally used winter road.

The funding and time allowed for the present study, required the scope of the cost-benefit analysis to be narrowed considerably and for it to rely more on a qualitative comparison than on a fully monetized analysis.

2.1 Qualitative Cost-Benefit Comparison

When considering the range of issues associated with heliportable exploration drilling, it is clear the government must balance a broader set of social and economic costs and benefits associated with heliportable drilling compared with the petroleum industry. The petroleum industry has a primary objective of exploring for and recovering oil and gas reserves with the least hard cost. Some participants in this sector have invested considerable effort toward local and social environmental improvements in order to help offset impacts, promote a more stable operating environment and as a matter of corporate philosophy. Factors which affect the public and First Nation's acceptance of oil and gas development can still have significant cost implications for the industry through either delays required for consultation and/or pressure for activity exclusion or other restrictions. A summary of the range of primary cost and benefit variables associated with heliportable exploration drilling are summarized in Table 1. Depending on the category, the cost or benefit may be more immediately felt by the government, the public, industry or shared by all groups.

The argument in favor of heliportable drilling invariably focuses on it's clear potential to avoid a wide range of environmental damages associated with oil and gas development. In conventional road accessed wells where the access road is aggressively reclaimed the year after drilling, the "costs" or impacts on wildlife and fisheries (and the direct use of these resources) are relatively short-term (*e.g.*, 1 to 2 years), provided the access road was not routed through limited areas of particularly high value, slow recovery habitat and does not become a major predator or human use corridor. In the case of wells which are suspended following exploration drilling, there is potential for more prolonged "costs" related to access and terrain disturbance due to potential lag time between drilling and the decision to abandon or re-enter the well. In some cases, this can mean the well and it's access road are not reclaimed for many years.

While rapid and aggressive reclamation (*e.g.*, recontouring, use of heavy rollback) in part mitigates many of the impacts on wildlife and fisheries, long-term impacts to the overall landscape aesthetic remain. It is the "cost" of this latter impact that is particularly hard to quantify for comparison against any incremental costs (including any perceived differences in safety or blow-out related environmental protection associated with heliportable drilling).

TABLE 1

COST BENEFIT ANALYSIS OF HELIPORTABLE DRILLING IN THE MK [1]

Costs	Benefits
1. Environmental	
Short to medium term displacement and/or energetic effects on mountain sheep, goats, grizzly bear and other species. While the probability of a blow-out is very low, without adequate planning and preparation, potential exists for increase in environmental damage where a liquids intensive blow-out occurs. The probability of this type of event occurring will be site-specific and very low due to the anticipated extra care in site selection and design and high level of training, planning and supervision associated with heliportable. Larger well site requirements and probable requirement to locate camp near well site may result in reduced ability to avoid some acute impacts in the well site area.	Eliminates short to medium term (*e.g.*, 1+ years) conventional exploration road impacts (longer benefit if well suspended) to fish and fish habitat (due to access and erosion/siltation). Eliminates short-term (1 year) and potentially long-term (>2 years) impacts to wildlife associated with habitat loss, fragmentation, increased human and potentially predator access. Eliminates long-term (>2 years) loss of forest cover and associated habitat fragmentation. Eliminates short and potentially long-term adverse impacts on human use of fish and wildlife resources.
2. Public Recreation and Tourism Investment in Northeastern BC	
On a per well basis, short-term noise associated with heliportable drilling may result in loss of tourism opportunities on a site-specific basis.	Eliminates long-term (>2 years) landscape aesthetic impacts. Would likely help maintain or promote long-term tourism in northeastern BC through reduced landscape impacts and public relations value. Would likely help maintain or promote long-term guide outfitter business in northeastern BC through reduced landscape impacts.

TABLE 1 Cont'd

Costs	Benefits
3. Investment and Employment in BC	
Companies may not bid on tenures subject to heliportable requirement or where there is uncertainty as to criteria used to determine its application. May divert attention to land elsewhere in, or outside the province. Reasons for this would include perceived capital risk (cost) relative to potential gain; unfamiliarity with technology and cost implications, perceived increased safety and emergency response handicaps/compromise. Effect may be exaggerated where industry obliged to assume heliportable operation with no road access. Reduced employment in conventional road construction Increased forestry and/or mining costs as fewer roads subsidized by oil and gas development.	Creates more certainty for tenures if government policies/regulations identify areas or site criteria where heliportable exploration is required, appropriate or optional. More marginal tenures that are not subject to heliportable guidelines may become more attractive/valuable. Promotes new technology and diversification of drilling industry (including low impact alternative technologies). Increased employment in helicopter industry. New joint venture training career opportunities and new technology exposure for First Nations and others. Reduced loss or alteration of productive forest cover caused by road construction. Greater allowance of drilling outside of winter season may benefit service sector. May increase amount of seismic related expenditure and employment in areas where heliportable is required or probable.
4. Public Perception and Support	
Some groups or individuals may perceive the reduced expansion of road networks by the oil and gas industry as denying desirable new access opportunity for recreational purposes. Some groups or individuals may perceive the use of heliportable drilling to be a panacea for all well sites and expect it to be used everywhere.	Heliportable drilling appears to have a relatively high degree of public support. Government may be perceived on average to be more environmentally progressive or responsible. May reduce amount of public resistance to other frontier exploration efforts (*i.e.*, perceived impacts reduced to more readily accepted threshold). Gives the oil and gas industry a showcase of new technology and best environmental practice. Consistent with recent planning initiatives, LRMP and pre-tenure plans that emphasize alternates to road development.

TABLE 1 Cont'd

Costs	Benefits
5. Exploration and Development Economics	
Initial economic cost contingent on length and location of road alternative, reclamation standard, and site-specific timing restrictions. Increased costs for short to medium length access relative to conventional road access where environmental and geotechnical constraints are few. No upfront road construction to off set pipeline construction costs or development well access if well successful. May slightly increase expenditures on seismic programs to increase certainty around drilling target. Potential significant costs if a water source is not available in close proximity to the site. Significant mobilization costs or scheduling requirements where rig with adequate depth capability is not readily available or must be procured from distant location. Potential to incur significant costs where there is a requirement to guarantee relief rig availability. May be significant increase in costs if rig and camp water have to be flown in. May be significant increase in cost for blow-out control (particularly containment and clean-up costs) where uncontrolled liquids release. May create precedent that forces use and/or more aggressive application of heliportable drilling in other locations with adverse incremental hard cost differentials.	*Initial economic benefit contingent on length and location of road alternative, reclamation standard and site-specific timing restrictions.* Reduced costs for planning, assessment, road engineering and approval (particularly with experience). Reduction in front end time for approvals and construction may accelerate time for tie-in and with it accelerate the revenue stream compared to sites requiring construction of long complex access and or interrupted drilling due to breakup or freeze-up. Eliminates cost of road construction and reclamation (and maintenance if carried through for exploration phase). Costs equivalent or reduced relative to conventional road access for longer more complex roads. May reduce drilling costs and increase probability of success due to better well site optimization and reduced pressure for environmentally driven directional drilling. May increase industry access to areas formally or informally off limits due to environmental sensitivity. Use of heliportable drilling will likely lead to a marketplace response (*e.g.*, increased rig availability at a lower cost) which will reduce the overall cost of future drilling using this approach and increase rig availability. Ability for summer drilling in some locations may provide a greater drilling activity period (current total winter season is 120 days for access construction and drilling). Helicopter activities could extend seasonally June to October or November to May, or even year round depending on site-specifics. The net effect may be a quicker turn around between exploration and production.
6. Time Required for Planning and Well licensing	
May be longer where alternative is short, simple road access (*e.g.*, adjacent to existing access corridor), unless heliportable rig is readily available and heliportable drilling protocols are well established.	Shorter where alternative is a relatively long, complex conventional road.

TABLE 1 Cont'd

Costs	Benefits
7. Occupational Health and Safety	
Minor reduction in ability to evacuate injured worker to hospital in Fort St. John or Fort Nelson under certain conditions (*e.g.*, icing conditions). Eliminates option to use access road as emergency escape route during sour gas blow-out. May be relatively high risk associated with operations in more confined locations (*e.g.*, narrow north-south valleys)	Equivalent or less risk of worker injury due to anticipated high level of training, planning and supervision associated with heliportable (may be dependent on well site location). Faster emergency medical evacuation under most conditions due to presence of on site service helicopter.
8. Blow-out Risk and Response Capability	
Minor reduced capability in rare situations where relief well required Reduced capability in rare cases where large volume uncontrolled liquids release occurs, particularly where contingency plan not in place.	Could be argued that there would be reduced risk of blow-out due to anticipated high level of training, planning and supervision associated with heliportable.

1. Costs and benefits assume a dry hole and that all reasonable planning and mitigation has been implemented.

2.2 Other Considerations

Heliportable drilling relative to conventional road access must be compared, on a site-specific basis, with whatever least impact, surface access alternative a given prospect may present. For example, a site may be readily accessed by use of an existing seismic line or road or through construction of a snow road, and in doing so, must be compared to the "costs" associated with a heliportable approach (as well as some of the benefits).

Forcing a company to assume large incremental "costs" for marginal environmental or social benefit will create a general disincentive for exploration where the potential return on investment is perceived as low.

3.0 CRITICAL FACTORS AND DECISION MAKING

At a broad policy level the most *Critical Factors* concerning the feasibility of heliportable drilling in BC involve the extent to which regulation, guidelines and process allow companies to maintain a high level of interest in petroleum exploration in northeastern BC, while at the same time protecting other core values.

Based on review of the various costs and benefits summarized in Section 2.1 and discussed previously in the companion reports, six *Critical Factors* were identified that are believed to represent the most important issues when considering the site-specific feasibility of heliportable drilling. These are:

1. Environmental Sensitivity
2. Availability of Low Impact Alternatives
3. Helicopter Site Risk
4. Capital Cost
5. Blow-out Risk and Worker Safety
6. Presence of Sour Gas

Environmental Sensitivity, Availability of Low Impact Alternatives, Helicopter Site Risk and Capital Cost have in our view a more direct bearing on feasibility and will vary widely from site to site. Industry's demonstrated ability to manage blow-out risk and to operate safely in sour gas environments, combined with the probable level of planning and expertise, which would be applied to heliportable drilling, suggests that blow-out risk and presence of sour gas, should be less critical considerations concerning heliportable drilling feasibility. These two factors are also relatively independent of cost. However, it is clear that a low probability blow-out, involving high volume uncontrolled liquids release would have potentially substantial cost implications on a heliportable project particularly in the absence of adequate contingency planning

Information obtained during this study suggested that WCB requirements regarding provision of emergency medical care can be adequately met with first aid stations as are routinely in use at sites lacking 24-hour egress to hospital service. As such, the requirement to have a guaranteed 24-hour air or land egress capability is not considered a *Critical Factor* in decisions around heliportable feasibility. Ensuring that heliportable sites are proximate to existing road access may increase perceived ability to deliver emergency medical service, however, other factors such as the potential premium for heliportable construction and supported drilling in such cases would tend to negate the advantages of proximate emergency land access.

While there appears to be a reasonable heliportable rig supply available in North America (for wells 3,400 m or less), the potential remains that these rigs or deeper-rated foreign rigs may or may not be available as and when needed unless sufficient lead time is taken. As discussed in the Economic Report, mobilization of a foreign rig could exceed $1 million US and proportionately affect drilling economics and scheduling. This constraint becomes larger where there is also a perceived or actual requirement for an on demand standby relief drilling rig.

Key considerations associated with the six feasibility criteria listed above are summarized in Table 2.

TABLE 2

CRITICAL FACTORS AND CONSIDERATIONS FOR HELIPORTABLE DRILLING

Critical Factor	Key Considerations
Environmental Sensitivity	occurrence of habitat identified as significant and/or unique (*e.g.*, existing and future formally designated high sensitivity MK habitats, sheep and goat habitat)
	fish habitat and number of watercourse crossings required for the access road
	level of construction disturbance and ease of reclamation of the access road and well site
	occurrence of discrete areas important to First Nations
	occurrence of discrete areas with high public recreation value
	occurrence of areas with more sensitive and high visibility landscape aesthetic
	occurrence of species and site-specific activity timing restriction
	potential to reduce habitat or landscape indicator below some threshold (*e.g.*, unmodified habitat supply, road density, proportion of unroaded watersheds, stream crossing density)
Availability of Low Impact Alternatives	option to make snow/ice roads with "minimal" clearing/grading
	availability of existing useable linear disturbance (*e.g.*, road, seismic line) in "close" proximity to location
	ease of reclamation (shrub lowlands, dry creek bed, meadow/muskeg complex)
	option for river travel "close" to location
	option to use low ground pressure vehicles (*e.g.*, Commanders) to access site with "minimal" clearing and grading
Helicopter Site Risk	is site located in high risk location (*e.g.*, confined valley bottom, especially north south valley, or alpine cirque location)
	are there alternate flight paths to access site
	is site prone to unusual extreme weather
Capital Cost	cost of conventional or low impact alternative access construction vs. heliportable operation
	availability of water at or near site
	rig mobilization charges
	is relief rig capability required
	reclamation standard
	potential for interrupted drilling for winter access only sites
Blow-out Risk and Worker Safety	quality of seismic data
	probability of lost circulation
	predictability of anticipated reservoir pressures
	water contact
	underbalanced vs. overbalanced drilling (controversial for some)
	exploration well vs. development well
	blow-out contingency plan and site suitability for containment and evacuation
Sour Gas	probability of sour gas
	sour gas release emergency response plan

Each of the *Critical Factors* affect the overall feasibility of heliportable drilling. Some are strongly affected by individual site characteristics, others less so. In all cases, they can be expected to be subject to differing valuations depending on perceptions of environmental sensitivity and willingness to accept varying degrees of risk, including risk that the costs of heliportable drilling will, if broadly imposed, deter some oil and gas investment.

Information obtained during the course of this investigation, suggest that the actual risk of blow-out and/or worker injury on a heliportable drilling program would likely be very low, possibly lower than a conventionally accessed well given the anticipated emphasis that would be imposed on worker safety and well control. A variety of mitigation and contingency measures are also available to further reduce the consequence of what is likely to be a very rare event. It should be recognized that allowing the potential occurrence of an extreme sour gas blow-out event (night time blow-out involving multiple injuries and high volume uncontrolled liquids release) to dominate decision making at the expense of decisions which would on average result in significantly reduced impact to the identified environmental values of the MK, will tend to frustrate achievement of long-term resource management objectives for the area.

3.1 Decision Making

At least three approaches to decision making can be used in regard to assessing heliportable feasibility: formal quantitative cost benefit analysis as discussed above; quantitative ranking of individual sites or areas; and or through a collaborative decision making process. None of these approaches are necessarily exclusive. Their outcomes may be that heliportable drilling is required in certain areas, under certain conditions, at the companies' discretion, or not at all.

Applying rankings and scores to the identified *Critical Factors* in terms of whether an individual site or region within the MK is more or less suitable for heliportable drilling can be used to systematically evaluate the overall feasibility of the site or area for heliportable drilling. It also illustrates the sensitivity of the evaluation to the various factors and the importance assigned to them. This exercise only has merit where it is accepted that heliportable drilling is an acceptable alternative and that, with the mitigation measures suggested, the incremental risks associated with heliportable drilling are generally small. Risk of blow-out, if it is included in a ranking system should be, in this case weighted very low relative to other factors.

Potential site or area characteristics for each *Critical Factor* that could be assigned to different heliportable suitability ratings (*e.g.*, Low, Moderate, High) are outlined in Section 3.2. These ratings can then be converted to a numerical score, summed and used to rate sites or areas and/or to guide a decision where the site rating exceeds some value or at very least appears to have a number of favorable rankings. Use of a threshold value is an arbitrary measure, however, values such as 75% of the maximum suitability score do have an inherent strength, provided the categories or factors are relatively discrete and/or fairly weighted. For example, using five critical environmental factors and one generic critical cost factor would, assuming factors are equally weighted, bias the process in favor of purely environmentally based decision making, just as splitting out multiple cost factors and having one generic environmental factor would bias decisions in favor of economic differences.

3.2 Heliportable Drilling Suitability and Critical Factors

3.2.1 Environmental Sensitivity

The environmental sensitivity of a potential well site or area has a strong bearing on whether or not exceptional mitigation measures (*e.g.*, heliportable drilling or low impact alternative) are warranted relative to their additional expense and/or risk. Areas of sites which have high environmental sensitivities and for which no reasonable low impact alternative is available, would in general be considered more suitable for heliportable drilling.

Test: *Will heliportable drilling avoid a significant environmental impact?*

Heliportable Suitability Ranking	Potential Environmental Characteristics
High	Conventional access requiring substantial habitat disturbance/modification or strong seasonal timing conflict will be required through or in very close (using distance with minimal topographical considerations) proximity to core wildlife habitat (*e.g.*, critical winter habitat, calving/lambing area, large mineral lick, confined movement corridor).
	Multiple (number and/or sensitivity rating-based) fish-bearing watercourse crossings requiring graded approaches will be required.
	Access will require significant (*e.g.*, possibly length based) new, long-term disturbance to forested areas, alpine habitats or other unique or sensitive vegetation communities.
	Reclamation will be difficult and long-term undertaking
	Access will result in disturbance to site-specific area of importance to First Nations, recreationist or guide/outfitters.
	Access development will create long-term high visibility impairment of landscape aesthetic.
	In the event permanent access is required, access control will be difficult, expensive and likely be challenged.
	Surface access will reduce the habitat or landscape supply below some referenced standard.
	Land use plans identify site-specific wilderness or other values in conflict with least impact road alternative
Moderate	Characteristics identified for "High" ranking only moderately expressed.
	Land use plans identify general integrated management and limited site-specific values in conflict with least impact road alternative.
Low	Conventional access will not require substantial habitat modification or strong seasonal timing conflict with core wildlife habitat.
	Multiple crossings of fish-bearing watercourses and/or graded approaches will not be required.
	Access will not require long-term disturbance to forested areas, alpine habitats or other unique vegetation communities.
	Reclamation will not be difficult or long-term.
	Access will not result in direct conflict with disturbance to site-specific area of importance to First Nations, recreationist or guide/outfitters.
	Access development will not create long-term high visibility impairment of landscape aesthetic.
	Land use plans indicate enhanced development/agriculture settlement and only limited site-specific values in conflict with least impact road alternative.

3.2.2 *Availability of Low Impact Alternatives*

The availability of low impact alternatives is an important consideration in determining the feasibility and applicability of heliportable drilling. Low impact surface access alternatives may or may not be mirrored as cost effective as heliportable drilling depending on site characteristics. While low impact alternatives may be available, these will usually involve some increased level of environmental impact relative to heliportable operations. It is clear that the net benefits of heliportable drilling compared with a low impact alternative are all scaled in proportion to the environmental sensitivity of the site or area under consideration and the projected level of disturbance associated with surface access.

Use of these alternatives or the potential to use them in an emergency, would tend to reduce concerns about low probability events such as blow-outs and worker safety associated with heliportable drilling (recognizing that planning and preparation which would be applied to a heliportable drilling program would significantly reduce the probability and consequence of either).

Low impact alternatives are usually winter access and highly weather dependent in a constrained drilling season. This has resulted in duplication of costs for low impact alternatives where there was insufficient opportunity to complete drilling in a single season and remobilization was required. There may be opportunities to combine low impact alternatives with heliportable drilling in a cost and environmentally efficient manner to extend the drilling season to complete a project.

Test: *Are there low impact alternatives to heliportable drilling for the site or area?*

Heliportable Suitability Ranking	Alternate Access Characteristics
High	No equivalent or near equivalent low impact alternative available.
Moderate	An equivalent or near equivalent low impact alternative is available (for greater than some percentage of the route, for example 50-75%).
Low	An equivalent or near equivalent low impact alternative is available (for greater than some higher percentage of the route, for example >75%).

3.2.3 *Helicopter Risk*

Helicopter risk refers to the inherent site characteristics of the proposed well site from the perspective of having to support the drilling operation. This factor can be expected to vary from site to site. Very few sites are truly inaccessible to helicopter, however, the more constrained the site is (either physically and or climatically) the more frequently "on demand" helicopter support is likely to be interrupted. While it is anticipated that few sites would actually be inaccessible for more than 24-hours the probability would increase in some cases. It should also be recognized that in cases where the well site was within a very low suitability location for helicopter access that mitigation could be achieved by lengthening the distance between the camp and well site such that good helicopter access is afforded the camp. Some least impact access to the camp would be required in this instance.

Test: *Does the site and the proposed air access routes (including alternates) pose high risk to helicopter operation?*

Heliportable Suitability Ranking	Helicopter Risk Characteristics
High	Site occurs in broad valley.
Moderate	Site occurs on broad, high sub-alpine or alpine location.
Low	Site occurs in narrow, deeply incised north-south valley or confined cirque.

3.2.4 Capital Cost

Cost suitability as defined here refers to the hard dollar cost differential between heliportable exploration drilling and more conventional surface-based access alternatives. It does not address the long-term investment implication of a generic requirement for heliportable in specific portions of the MK or a blanket, general direction specifying heliportable drilling as the only acceptable alternative.

For a given exploration project, determining what this cost is could be based on an analysis provided by the proponent using a generic spreadsheet guide for construction. The government could then decide the following: a) that companies will not be expected to absorb cost differentials above a certain amount and that the government will provide some form of off-setting fiscal relief; b) that the differential is so slight or actually cheaper using heliportable that other factors will be the key determinant; and c) that companies have been made aware of the sensitivities prior to bidding on the tenure and will be expected to absorb cost differentials (*i.e.*, where heliportable remains substantively more expensive.

Tenure bids may be reduced or companies may be less willing to pursue a target if they are responsible for large heliportable drilling differentials unless they believe the well has a high probability of economic success and that at least seasonal surface access would be guaranteed for operations. Where this is not the case, a the company would have to do a more detailed cost analysis addressing projected long-term operating costs based on a fully heliportable operating mode.

Government regulatory requirements concerning the allowable timing of operations in certain areas, requirements for use of low impact winter roads and the reclamation standards all will have significant implications for the cost of surface accessed drilling locations in the MK and any differential between heliportable drilling and other approaches.

Test: *Will a heliportable drilling program cost more than the alternate surface access alternative?*

Heliportable Suitability Ranking	Cost Characteristics
High	Heliportable substantially less expensive by some percentage (*e.g.*, >25%) than alternate surface access and reclamation.
Moderate	Heliportable approximately cost neutral by some percentage (*e.g.*, ±25%) with alternate surface access and reclamation.
Low	Heliportable substantially more expensive by some percentage (*e.g.*, >25%) than alternate surface access and reclamation.

3.2.5 Blow-Out Risk and Worker Safety

Concern over the ability to avoid blow-outs and adequately respond to them, suggests that sites and/or areas should be considered from a blow-out risk perspective. Blow-out risk in Alberta and BC has been determined to be very low. The importance of this consideration is dependent on the government and industries perspective on limits of acceptable risk. This perspective should only be shaped after thoughtful consideration of the magnitude of risk in light of the mitigative measures to further lessen the risk that would be expected in conjunction with a heliportable drill. As mentioned, at several points in this study, these include: higher levels of project specific planning, implementation of industry standard recommended practices; use of only appropriately experienced drilling crews; high levels of supervision; contingency stockpiling of critical parts and consumables; and maintenance of onsite heavy equipment or rapid access to it. Based on review of typical blow-out control procedures it appears that a relief rig has an extremely low probability of being required for well control and capping, such that delays in getting a relief rig onsite would have no influence on the time to control and cap a blow-out.

Conducting additional seismic work in areas of greatest uncertainty may further help address these concerns. To some extent, many of the features which lead to an exploration well site's reduced risk of blow-out, also are associated with industry certainty around the geology at given location.

Test: *Will the site have a high risk of a blow-out?*

Heliportable Suitability Ranking	Blow-out Risk Characteristics
High	Good quality seismic data. Confidence around probable reservoir pressures. Unfavourable geological characteristics (*e.g.*, high levels of fracturing, karst features) Commitment to use highly experienced and well supervised drilling crews. Well site amenable to containment and management of released liquids.
Low	Poor quality seismic data. Considerable uncertainty around reservoir pressures. Favorable geological characteristics (low levels of fracturing and probability of karst formations). Well site not amenable to containment and management of released liquids.

3.2.6 Sour Gas

Presence of sour gas and concern over the ability of personnel at a heliportable well site to achieve the same or near equivalent level of emergency response and safety suggests that the probability of encountering sour gas should be included in the assessment of a site's suitability for heliportable drilling. Protocols (*e.g.*, rig ignition) and site planning options (*e.g.*, well site and camp location, having multiple heli-accessible, foot accessed escape routes/nodes) are available which are suggested to achieve response at least equivalent to conventional road accessed drilling. In our assessment, these measures would provide equivalent levels of response and reduced overall probability of needing to respond to a sour gas release (based on anticipated overall reduced probability of a blow-out). From our consideration of sour gas blow-outs, it is not readily apparent that the presence of an access road has reduced the occurrence of sour gas related worker injuries for any blow-out. To the extent a properly planned and executed heliportable sour gas drill does increase risk, it is anticipated to be a relatively small noncumulative increment. This is based on the belief that the probability of a blow-out involving direct hazard to a worker is lower and the probability of road access considerations being involved is even lower yet.

Test: *Will gas bearing formations at the site tend to be sour?*

Heliportable Suitability Ranking	Sour Gas Characteristics
Higher	Triassic drilling target (lower pressure, lower permeability, variable but lower sour content)
Moderate	Mississippian drilling target (moderate pressure, high permeability, low to moderate sour content)
Lower	Devonian drilling target (high pressure, low permeability, high sour content)

4.0 DECISION MATRIX

A decision matrix or spreadsheet approach using the above referenced *Critical Factors* and rankings can be used to evaluate the relative feasibility of heliportable drilling for a particular site or smaller homogeneous area (Table 3). Where it is applied to a larger heterogeneous area, the determination would tend to average out characteristics of the area and increase the likelihood that decision making is sub-optimal.

As discussed in Section 3.1, suitability rankings (*e.g.*, Low, Moderate and High) can be assigned values (*e.g.*, 1,2,3) for each *Critical Factor*, and then the overall value summed and compared against an overall numerical suitability threshold. Each *Critical Factor* can also be weighted such that its actual importance in the decision making process is better reflected.

Where the evaluation results in a site exceeding some threshold, then heliportable drilling could be assumed feasible and either required or expected. To illustrate the application of this approach, two hypothetical examples are presented below (Scenario 1, Scenario 2 and Table 3). The feasibility threshold is set at a minimum of 75% of the maximum suitability/feasibility score.

Scenario 1: Triassic target with good seismic control. 5 km road that includes 2 km along an existing seismic line and 1 km along open muskeg, in gentle terrain, valley bottom location, black spruce forest grading mature white spruce forest, crosses one fish-bearing creek,

Scenario 2: Devonian target with moderate seismic control. 20 km road that includes 2 km along an existing access trail, 4 km along willow flats, 14 km requires graded road construction including 1 km alpine construction and 3 km steeply ascending side hill construction, 14 km of clearing through subalpine Engelmann-subalpine fir forests, site in moderately confined north-south valley, 1 km immediately adjacent to high value wildlife habitat, less than 500 m from large mineral lick and First Nations traditional use site, crosses four fish-bearing streams and the Kechika River,

TABLE 3

DECISION MATRIX

Critical Factor	**Case 1 (5 km Low Sensitivity Well Site)**				**Case 2 (20 km High Sensitivity Well Site)**			
	Suitability Ranking	Raw Ranking Score	Weighting	Weighted Score	Suitability Ranking	Raw Ranking Score	Weighting	Weighted Score
Environmental Sensitivity	Low	1	2	2	High	3	2	6
Availability of Low Impact Alternatives	Low	1	2	2	High	3	2	6
Helicopter Site Risk	High	3	2	6	Low	1	2	2
Capital Cost	Moderate	2	1.5	3	High	3	1.5	4.5
Blow-out Risk and Worker Safety	High	3	0.5	1.5	High	3	0.5	1.5
Sweet Gas vs. Sour Gas	High	3	0.5	1.5	Low	1	0.5	0.5
TOTAL		13		16		14		20.5
% of Maximum Score (18 unweighted; 25.5 weighted)		72%		63%		78%		80%

Raw Ranking Score: Low Suitability = 1, Moderate Suitability = 2, High Suitability = 3
Threshold Feasibility Score: 75%

From our example above, it would appear that the 5 km scenario was not a suitable candidate for heliportable drilling where critical factors were unweighted and even less so when these factors were weighted. For the 20 km scenario, the prospect would appear to be suitable for heliportable drilling and is even more so when importance weighting is included. It is clear that the weightings and scoring could be manipulated to achieve any result, however, in a collaborative and objective process, the exercise does provide for a systematic approach to evaluation that can be used to identify key turning points in the decision making process, assessing whether or not the *Critical Factors* have been fairly considered and ultimately used to arrive at an optimal decision.

5.0 CONCLUSION

On an international scale, heliportable drilling has been demonstrated to be a practical, cost effective, environmentally sound approach to exploration drilling. The locations in which this has been demonstrated have shared one or more of the following characteristics: the hard cost of road construction and maintenance clearly exceeded the cost of heliportable drilling and the time required to undertake it; the prospects had potential to yield relatively high rewards; and/or there were significant environmental/social concerns concerning road development. In many or possibly all of the international locations where this activity is occurring, it could also be argued that the ability to enforce access road closures and the degree of public respect for these may be less than in BC though this is speculative.

In a general sense, there does not appear to be a firm basis for concluding that heliportable drilling in the MK is not feasible and should not be included in the range of low impact options acceptable to the MK managers. There will, however, be site-specific circumstances where it is relatively more or less feasible.

Within the MK it is clear there are likely to be locations proposed for drilling which will have conventional initial access costs exceeding that of heliportable access, where the environmental consequences (primarily landscape aesthetic unless heliportable operations also pursued) of exploration roads will be high and where the potential economic reward of a prospect may be high. Heliportable drilling would appear to be a feasible, environmentally sound and safe approach to petroleum exploration in these cases.

In cases where estimated costs for heliportable drilling significantly exceed conventional surface access approaches (with expected emphasis on low impact approaches) the feasibility will depend on industry's valuation of the economic risks, the extent to which these can be offset by incentives and government and industry's confidence in the ability to adequately manage environmental and human safety risks. From the material examined there appears to be reasonably compelling evidence to suggest that these latter factors can be managed to a level at least equivalent to that associated with conventional surface access approaches.

6.0 RECOMMENDATIONS

The following recommendations are provided:

1. Heliportable drilling should be included in the range of land use management tools used by MK resource managers.
2. Developing a clear policy with regard to the use of heliportable drilling should be undertaken in order to reduce uncertainty within the industry and among resource users. This will likely provide benefits for all groups concerned and lead to the more efficient use of capital and development of energy resources.
3. A set of best practices and guidelines should be developed which would focus on needs for overall planning and coordination, training/staffing requirements, environmental protection, blow-out prevention and response, underbalanced drilling and safety. The potential applicability of "casing drilling" to significantly extend the depth range of available domestic heliportable rigs should also be explored further. Consideration should be given to collaboratively undertaking these initiatives through the Canadian Petroleum Safety Council or equivalent provincial body.
4. Consideration should be given to facilitating an initial heliportable exploration drill as a pilot study in the MK to facilitate the implementation and refinement of any subsequent guidelines and procedures as well as to field test the suitability of this approach. This recommendation follows a similar recommendation made to the OGC by Berlie (1995). It was recommended that "close monitoring, and analysis of every facet of the program at a research level, including weather, equipment serviceability, logistics, coping with drilling incidents, safety and response times" be conducted to allow further evaluation of the overall feasibility of this approach.
5. As a planning tool and to assist with decision making, it may be useful to identify and map the areas where the potential for low impact alternatives exist, as well as areas that may be more suited to helicopter access only (*i.e.,* designate as heliportable only). The varied topography, landforms, aspects and habitat community types within the MK, create circumstances where heliportable drilling and/or low impact access road alternatives may be more or less suitable. Locations that provide the opportunity for low impact access include broad valleys, shrub lowland habitats, meadow and muskeg complexes, dry creek beds and areas where existing access already exists. Heliportable drilling may be more favorable where new access is required for a long distance and/or in an area that is difficult to reclaim (*e.g.,* steep slopes, alpine ridgeline) and where climatic conditions do not pose a high level of risk for flying.
6. Where the risks associated with heliportable drilling are deemed acceptable, guidelines should be prepared which are identified prior to a land posting and are location specific or are attached to a land posting, and known prior to bids being issued. These guidelines could be modeled after the heliportable suitability factors identified for some or all of the *Critical Factors* identified in Section 3.0 above.
7. Consideration should be given to increasing the feasibility of heliportable drilling by providing financial incentives to the petroleum industry where commitments are made to

use this access approach. These incentives would have to be based on a reasonable comparison with alternate low impact surface access that would be otherwise pursued. The need for incentives may decrease as the marketplace responds to the demand (*e.g.*, by procurement of deeper rated and/or more rigs). Options to reduce the economic premiums that may be associated with heliportable drilling could include the following incentives:

a) royalty relief (*e.g.*, 30-50%) on existing or any future production;
b) increased exploration acreage retention for heliportable wells;
c) tenure extensions;
d) bid bonus applied to land sales where proponent commits to heliportable drilling (*e.g.*, land bid prices which did not include commitments to heliportable drill in certain locations or under certain clear conditions would be discounted (*e.g.*,10%) thus favoring bidders who would commit).

8. As many of the benefits of heliportable exploration drilling are eliminated where road access is developed, the practicality and economics of heliportable operations should be investigated and reported.

7.0 REFERENCES

Berlie, E.M. 1995. Alternatives for Conducting Oil and Gas Exploration in Sensitive Areas of Northeastern British Columbia - A Preliminary Study. Prepared for the Engineering and Operations Branch, Ministry of Energy, Mines and Petroleum Resources (Service Contract #95-22). October 1995. 29 pp + appendices.

Moore, J.L. 1995. Cost-Benefit Analysis: Issues in its use in regulation. CRS Report for Congress. Environment and Natural Resources Policy Division. National Council for Science and the Environment.